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sorghum & millet

Food Production and Use

Editors: Sally Vogel and Michael Graham

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Foreword

To complement efforts in field and laboratory experimentation in sorghum and millet breeding and selection, this workshop brought together food scientists and home economists from Ethiopia, India, Kenya, Nigeria, Sudan, Tanzania, Uganda, and Canada. The purpose of the meeting was to facilitate the exchange of ideas on local sorghum and millet preferences, to gather information on the current use of sorghum and millet in the participants' countries, to discuss methods of establishing utilization and consumer-product tests, and to establish a procedure for collecting sorghum samples to be sent to a central place for analysis of quality.

The presentations covered the whole realm of sorghum and millet quality and use: harvesting, drying, threshing, storage, milling, enrichment, and marketing. In addition, a sorghum breeder's viewpoint on the potential for improvement and a home economist's view on utilization and consumer-product tests were presented. On the last day of the workshop the participants prepared a few of the most common sorghum and millet foods eaten in their countries. As a result, each participant was convinced that there was sufficient similarity in certain foods and beverages for the same criteria of quality to be applied in all sorghum and millet screening programs.

The information from the various papers has been combined in order to give an overview of sorghum and millet use throughout the area and the recommendations and conclusions made at the workshop have been summarized. Special thanks are extended to all the participants not only for their excellent presentations but also for their active participation in the very fruitful discussion sessions. It is our hope that the success of this workshop will foster better communication among the countries and eventually lead to the establishment of a successful screening method that will allow plant breeders to identify sorghums and millets that have the quality characteristics preferred by the consumers.

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Millet-based meals are enjoyed by thousands where rainfall is scarce and unpredictable.

Production and Use

Sorghum and millet enjoy considerable importance in many countries as a human food. In drier regions in particular, sorghums and millets are very important (Table 1). Although in some countries their consumption has been reduced by the introduction of maize and rice, sorghum and millet are well adapted to a wide range of ecological conditions and are able to produce good yields of grain under conditions unfavourable to most other cereals. Thus, sorghum and millet remain important components of the diets in many countries, and their use is reflected in many traditional dishes.

In Kenya, sorghum and millet are grown primarily for human consumption. The production of sorghum is concentrated in the warm and slightly drier regions of Western and Nyanza Provinces, as well as in the Machakos and Turkana Districts. Yields of well-managed crops are usually between 500 and 1700 kg/ha, but hybrids coupled with good husbandry yield much more. Annual production has not been established because little attention has been paid to the cereal. Unfortunately, sorghum and millet are vastly underrated cereals in Kenya and have almost been replaced by maize, preferred for its white colour and bland flavour. While at least equal to maize in nutritive value the price of sorghum is considerably lower. Thus most of the sorghum is grown on a subsistence basis and does not enter formal market channels.

Sorghum and millet are traditionally consumed in the form of *ugali* (stiff porridge), *uji* (thin porridge), and a wide range of fermented beverages, including a local brew known as *busaa.* In addition, several recipes using milled sorghum grits or flour have been developed and tested for acceptability by the University of Nairobi, Home Economics Department. Unfortunately the limited availability of milled products has restricted the utilization of sorghum. Today most *ugali* is made using maize flour, but sorghum and millet are still considered essential *uji* ingredients. It is estimated that three-quarters of all sorghum produced is utilized in beer production.

Although most Kenyans do not attach any special spiritual or medicinal properties to sorghum and millet consumption, in certain communities in Western and Nyanza Provinces, sorghum *ugali* cooked in milk and *ghee* (clarified butter) is served as a specialty for in-laws and other important guests. In Central Province, fermented sorghum/millet *uji* is prepared for lactating mothers to increase milk output.

In Uganda, sorghum is an important staple in the drier parts, such as Karamoja, Kigezi, and parts of Teso and Acholi, and is grown on about 230 000 ha. In central Uganda it is planted twice a year. The grain types vary in shape and colour, from white to yellow, red to brown, to black. White types are generally preferred for food, red types for brewing. In some areas sorghum is also mixed with animal feeds, and the young sorghum forage is fed to cattle.

Millet is the main staple food in Acholi, Lango, and Teso, and supplements other staples such as plantain, sweet potato, and cassava in Bugisu, Busoga,

Table 1. Characteristics of sorghum and millet cultivation in various countries.

Country	Crop	Region	Most common varieties	Yield	Price	By-products
Kenya						
	Sorghum	Production concentrated in warm and slightly drier regions of Western and Nyanza Provinces and Machakos and Turkana Districts	—	500–1700 kg/ha (6–18 bags/ha)	—	—
Nigeria						
	Sorghum[1]	As far south as Iseyin in the Western State and almost everywhere in the Northern State	Fara fara, Jigare, Njigare	≈ 700 t/ha (1974–5)	12–14 kobo/kg (1975)	Fencing, thatching, mats, pith for toys, mulch for yams, feed
	Millet	Most important in most northerly regions where rainfall is less	Ex-Borno and Nigeria composite	≈ 600 t/ha (1974–5)	11–14 kobo/kg (1975)	—
Tanzania						
	Sorghum	All regions produce some, chief areas are in semi-arid central zone–Dodoma, Singida, and Shinyanga, Mtwara region to South, and Morogoro near the coast	Traditional: Konza, Msumbiji, Sagana; Improved: Sarena, Lulu Dwarf, Lulu tall, Dobbs Bora	≈ 600 kg/ha	Sh 1/kg	Thatching, fencing, firewood, fodder, bran used as chicken feed
	Millet	Same as for sorghum	Bullrush (*uwele*) finger (*ulezi*)	≈ 600 kg/ha	Sh 1/kg	
Uganda						
	Sorghum	Important staple in drier regions such as Karamoja and Kigezi, and parts of Teso and Acholi (Karamoja and Kigezi produce half of total production)	Yellow, red, black, and brown types; Serena, Dobbs Bora, Lulu (dwarf and tall), local names — Imumwa, Mugúsha, Gaya, Muwemba	≈ 500 kg/ha (approx. 108 800 t/yr)	Gov't price Sh 1/kg market Shs 4/kg	Leftovers from beer fed to poultry
	Millet	Main staple in Acholi, Lango, and Teso districts, and large quantities grown in Bugisu, Busoga, Bukedi, West Nile, Ankole, and Kigezi as supplement to plantain, sweet potato, and cassava	Local names of finger millet: Kal, Akima, Bulo, Buro, Bukwi, Anya	Total 340 000 t	Gov't price Sh 1/50 per kg market Sh 2/50 per kg	—
Sudan						
	Sorghum	Most important cereal crop, produced mainly in Eastern Sudan in rain-fed area. Very limited amount in Western Sudan and the irrigated area at the Gezira scheme	Mayo, Dabar, Safra, Gasabi, Feterita	1200 t/ha	Farmer 2–5 prasters/kg market 8–12 prasters/kg	Animal feed
	Millet	Limited to western region where it is grown on rain-fed area and consumed locally	Yellow and green	—	—	Stalks made into mats for winnowing
India						
	Sorghum	A major staple in dryland areas	PJ22K, SPV-86, CS 3541, Jowar (sorghum) 168, Moti, CSH-1	—	Higher than wheat price and fluctuates	Thin fine fodder and thick dehulling water used as animal feed
	Millet	Consumption depends on local production	Bajra (pearl millet), Ragi (finger millet), Variga, Korra (foxtail millet), Arika	—	—	—

[1] 60–70% of sorghum is grown as mixtures of: sorghum–millet; sorghum–millet–cowpea; sorghum–millet–groundnut.

Bukedi, West Nile, Ankole, and Kigezi. Annual production is about 340 000 tonnes, and it fetches about Shs. 2/50 per kg on the open market (gov't price Shs. 1/50 per kg). Most people grow their own millet and only town dwellers purchase it. Various kinds of dishes are made out of millet flour including a thin porridge (*obushera*), a stiff porridge (*ugali*), bread, and various beers. Beer is highly regarded and is used in payment for casual labour and for ceremonies such as marriages and funerals. The by-products from the beer are fed to homestead poultry.

In Uganda new millet must be offered to the ancestors before the family can eat it. The old people believe that this will please the ancestors and that blessings will then be received from them. Fine flour mixed with a little water and smeared on the skin of a child with measles is considered to help draw the measle rash from the body. Millet porridge is also a common weaning food. Additionally, millet is used in spirit beer given at funerals and served at decording ceremonies for twins.

Because producing finger-millet flour is a very laborious and time-consuming task, some people are growing other staples in the high-rainfall areas of Uganda. Nevertheless, millet bread has a high social value in the diet of the people in eastern and northern Uganda. In many areas, traditional celebrations are held for the new millet at harvest time, and the bread is served to important visitors and on important occasions. In the Buganda region, however, people prefer millet in the form of porridge served hot with either sugar or banana juice.

Sorghum and millet have long been grown in Tanzania as human food. Although many farmers have turned to maize in the last 20 years, a switch back to sorghum and millet is now starting to take place especially in the semi-arid areas where farmers are realizing the hazards of cultivating maize where rainfall is unreliable and in areas regularly suffering drought. Because sorghum and millet are grown at a subsistence level and are processed and consumed at home, production figures are difficult to document. Nonetheless, sorghum has shown a steady increase in production, a factor attributed to the success of research done to improve the seed, and campaigns to develop and improve traditional varieties so as to give better yields and reduce the time to maturity. By testing for varieties best suited to Tanzanian soil and climatic conditions, four improved varieties were identified that had improved yields, shorter stalks, ripened more quickly, and were not as readily attacked by birds in the field. These varieties were: *Sarena, Lulu Dwarf, Lulu Tall,* and *Dobbs Bora.* The traditional sorghum varieties are: *Kona, Msumbiji,* and *Sagana;* bullrush millet is known in Swaheli as *uwele,* finger millet as *ulezi.*

All regions in Tanzania produce some sorghum and millet, but quantity varies with soil and climatic conditions. In 1976–77 sorghum and bullrush millet covered an estimated 550 000 ha. The National Milling Corporation purchases of sorghum and millet have risen rapidly from 1000 tonnes in 1972–73 to an estimated 21 000 tonnes in 1977–78. People are encouraged to buy by weight, and by fixing the price per kilogram, the government is attempting to protect both the farmer and the consumer from seasonal price fluctuations.

Most of the sorghum and millet is used for food and for brewing, with priority in production given to those varieties with good brewing properties. About 5% of production is used for animal feed. Foods prepared at home use either flour, whole, or cracked decorticated grain. *Ugali* (stiff porridge), as in Kenya, is the chief dish, with *uji* a thinner porridge being second in popularity. *Ugali* can also be made with the addition of cassava flour (not more than one-third), but *uji* is not commonly made with mixed flour. A savoury dish known as *kande* is third in

popularity. It is made from whole or cracked decorticated grain boiled with beans or peas and seasoned well. Popped sorghum is favoured by school-age children in the central zone. *Pombe* (general Swahili word for various brews) is generally made from red sorghum varieties.

Although a limited number of people use bran for brewing, the bran is generally thrown in the fields or heaped near the house for the chickens to feed on. The only by-product that is used is the stalks, which are employed for thatching houses, constructing fences for compounds, as firewood, and as fodder for livestock.

In Tanzania, sorghum and millet are considered "food for the hungry," but for brewing they are considered a sign of prestige and the more one brews for sale or entertainment the higher one's social status. Beer is used in various celebrations, offered as a sign of gratitude, or used as part of a dowry. There are also a number of special properties associated with sorghum and millet. Some people give millet porridge to mothers who have just given birth for quick restoration of energy; whereas, finger millet porridge prepared with butter and milk is popular among lactating mothers (for example the Chagga people on the slopes of Mount Kilimanjaro). Others like the Wanyaturu of the central zone use finger-millet porridge to treat diarrhea in children. The Wanyirambe (also from the central zone) give sorghum porridge to children suffering from measles to speed recovery. In the Mara region, northern Tanzania, *obusara,* a special kind of millet porridge, is served after circumcision to promote rapid healing of the wound.

In Sudan, about 1.7 million feddan (0.7 million hectares) are under sorghum cultivation, with an annual yield in 1975–76 of about 2 million tonnes. Of this production about 0.5 million tonnes are exported. Although many sorghum varieties are grown, the most popular ones are Mayo (Milo in USA), Dabar, Safro, Gasabi, and Feterita. Mayo is the most popular variety because of its lighter coloured flour and soft endosperm, but the plants grow very tall and uneven and therefore cannot be combined. Dabar can be harvested with a combine and is therefore grown in the largest quantity. Its flour is white and it is replacing Mayo in most areas. Gasabi is very close in characteristics to Mayo, but its production is limited to irrigated areas. Feterita has a coloured endosperm, is early ripening, is inexpensive, and is used for local beer and as animal feed.

These grains are produced mainly in eastern Sudan in a rain-fed area, with limited amounts being produced in western Sudan and in the irrigated area at the Gezira scheme. Millet, on the other hand, is limited to the western region of Sudan where it is grown in the rain-fed areas and is consumed locally. Only two millet varieties are known (green and yellow), and they are used in the same manner as sorghum.

In the Sudan many foods are prepared from sorghum grain and flour. In the rural areas flour is used predominately for indigenous fermented beverages and *kisra* bread. *Kisra* is an unleavened bread that is the staple food throughout the country. It has been reported that up to 97% of the protein and 75% of the calories in the diet of the people residing in the Gezira irrigated area are derived from sorghum in the form of *kisra* and porridge (*aceda*). In urban areas, especially, wheat bread is now starting to compete with *kisra.* Sorghum flour (Feterita) is also used for the production of local beer (*marisa*) that is similar to Kenyan beer *busaa,* and for several nonalcoholic beverages including *hulumu, ábrey,* and *huswa.*

In Nigeria, sorghum and millet are by far the most important cereals in terms

of kilograms consumed per capita, and the people are traditionally committed to sorghum and millet. Sorghum is planted on 5.6 million hectares as far south as Iseyin and almost everywhere in the northern states; whereas, millet occupies 4.9 million hectares and is most important in the north where rainfall is reduced. In general more sorghum is consumed in the dry season with millet being more important in the wet season.

Throughout Nigeria, about 60–70% of the sorghum is grown in mixtures of: sorghum-millet; sorghum-millet-cowpeas; and sorghum-millet-groundnut. Because a large proportion of the sorghum and millet crops are intercropped, they are generally considered together. In the free-market situation under which sorghum and millet are produced and distributed, the process of adjusting the flows of the two commodities in response to changing supply and demand conditions has tended to make prices fluctuate from quarter to quarter and year to year, and the government is increasingly concerned with these large fluctuations.

The consumption of sorghum is mostly in the form of flour that is made into a thick porridge (*tuwo*) and served with soup or stew. Although both sorghum and millet can readily be substituted for each other in *tuwo* preparation, sorghum is much preferred to millet. Millet is more often eaten as *fura,* which is made from flour that is partially cooked, pounded, and formed into balls. Sorghum serves as the principal ingredient of the evening meals; whereas, millet is eaten more for lunch or the midday meal. Other thin porridges like *fura koko* and *kuna,* which are eaten during the day, are also prepared from these grains, as are a large number of deep-fried or water-cooked (dumpling-like) snacks.

Sorghum is not only used for food, it is also used in brewing. The most common variety used for beer production is called Jigare or Njigare, which is early maturing, has brown seeds, is weather and bird resistant, and has a floury endosperm and bitter taste.

As well, several by-products of sorghum and millet are used. The stalks are used for fencing, thatching, and for making mats (*pakiti*) used for sitting, drying grain on, and for doors. The pith is used for making toys for children. Sorghum stalks are preferred to those of millet and maize because they last longer and are taller. In Kwara state the sorghum leaves are used on the yam fields for mulching or capping the yam hills to conserve moisture and prevent excessive heat from reaching the planted yams. The dried leaves and round tillers of sorghum are used after the harvest for livestock feed, and if yams are not grown in the sorghum field after harvest, cattle, goats, and sheep are allowed to enter and graze on the stalks. Bran produced during milling is fed to the livestock. By-products, therefore, are very important and should be seriously considered when attempting to introduce or develop new varieties.

Sorghum and millet use is influenced by kinship and religion. Gifts of grain are exchanged in set kinship contexts such as childbirth, naming, circumcision, marriage, and death, and at fixed religious festivals, at the end of the fast, as religious alms, and after the harvest.

Next to rice and wheat, sorghum is the major staple in Indian diets, especially in the dryland areas. In addition to sorghum or Jowar, millets like Bajara, Ragi, Variga, Korra and Arika are also consumed depending on local production. In areas where irrigation has been introduced there has been an immediate shift away from these dryland crops to irrigated crops like rice, banana, sugarcane, cotton etc. An example of this shift in production trends is seen in southern India where rice is preferred not only because it is a fine grain and status symbol but also because it is comparatively easy to process and cook.

The processing and cooking of sorghum and millet takes more time than rice. Women going to work, either in the fields or in the community, have less and less time available for processing and cooking. Small-scale rural sorghum and millet processing mills, like the rice mills already available in India, could help promote the consumption of sorghum and millet.

Whereas rice or wheat are usually prepared in only one form, sorghum and millet are used in a variety of forms depending on the region. They are used to make *roti,* an unleavened flat bread, *ambali,* a thin porridge, and *sangati,* a stiff porridge. They may also be dehulled and steamed whole as is commonly done with rice.

In addition to these food uses, sorghum and millet by-products are also used. The washing water and fodder are fed to the cattle, and varieties that do not have as much or as fine a fodder or as dense washings as the traditional varieties are often rejected. It is believed that hybrids and high-yielding varieties are not as good and that they cause several minor health problems.

Sorghum and millet are important cereal crops in many countries, and with the development and testing of new varieties, improved production and processing methods, and the introduction of new products, the use of these cereals may be further expanded. Some of these possibilities are investigated in the following sections.

Processing

Harvesting and Drying

In areas where sorghum and millet are grown, the usual method of harvesting is hand-cutting using a small knife or scythe. Harvest time and grain moisture vary depending on the climate and planting time, but both grains are harvested in almost the same way. Usually the mature plants are cut and left in the field with the head exposed to the sun to dry; however, in parts of Kenya, the heads of sorghum are sometimes cut directly from the plant leaving the stalks in the soil. When dry, the heads are cut about 7.5–15 cm below the grain-bearing portion and taken home in bundles, sacks, carts, etc. to be stored. The size of each bundle varies between 18 and 36 kg in Nigeria.

Manual harvesting, particularly of millet, is a very slow, tiring job and is a serious drawback to production. In Uganda 50–70 man-days per hectare are required to harvest millet. In some countries, short-stalked sorghum varieties that grow to an even height at maturity are favoured because they can be combined. To the small-scale farmer, however, long stalks are resources used for fencing, thatching roofs, firewood, etc. Therefore, if short-stalked varieties are to be introduced acceptable substitutes for these important by-products must be provided.

No matter what the method of harvest, the grain must be dried before it can be stored. Sun-drying is generally employed and a moisture content of 10–12% is aimed at. The degree of dryness achieved by sun-drying is usually determined by the sound the grain makes when cracked between the teeth or occasionally by measuring the weight loss during drying. Depending on the season, temperature, and humidity, sun-drying is not always possible and various local methods are employed to further reduce the moisture content. In cases where sun-drying is not possible, the heads are often hung or placed above the fire to dry on special constructions, known in Tanzania as *ngoko*. In Nigeria, because sorghum is usually harvested during the dry season drying is not a problem. Millet, being a smaller grain, which dries quickly, is harvested during the rains and often left to dry in the field for 10 days. Further drying may be done at home on mats before the grain is stored. The farmers, in fact, consider it desirable for the millet to be beaten by the rain at least once as this is thought to increase the quality and palatability of millet foods prepared from the grain.

Traditional varieties of different crops tend to be open-panicle types that ripen after the rainy season. This eliminates many of the drying and storage problems encountered in varieties that mature before the rains end. When introducing new varieties this needs to be taken into account or the farmer will be more confident in having sufficient food by using his low-yielding traditional variety rather than gambling on a high-yielding variety that may be completely lost due to mould.

In any sun-drying process it is essential to realize that while the sun dries the grain the wind carries the moisture away. Therefore, due consideration must be given to making sure sufficient air space is left in the stacked grain and that there is maximum exposure to the direction of the prevailing wind. Traditional drying practices can be improved by taking the following steps to reduce crop exposure to pests in the field and to promote uniform and thorough drying. When stacking grain for drying in the head it should be at least 0.3 m off the ground. Generally stacks 2–3 m high and 0.6–2 m wide can be used to dry any grain in the tropics. The bundles in the first row are stacked with the heads facing out of the stack (i.e. bundles are placed tail to tail). The second row is laid at right angles to the first row, and the third in the same manner as the first. They are alternated like this all the way up the stack. This promotes uniform air circulation while holding the grain in place. The amount of grain in each bundle is the amount of food required for one step in the distribution process, i.e. food for 1–2 days. After drying, the grain is ready for threshing, storage, or distribution. In the long run, proper drying improves product quality by protecting the grain against mould damage and its accompanying off-flavours and damaged kernels, which are more difficult to process.

Threshing

Threshing methods were reported to be very similar in all countries. Traditional methods involve either beating the heads with sticks on the ground or in sacks, or using a mortar and pestle. The first step in all cases is to spread the heads on the ground, on mats, or on a special platform to allow the grain to dry. This is followed by the actual threshing with the sticks or in the mortar and pestle. The last step is winnowing to remove dirt and chaff before storage. This was reported to be the most common method in Tanzania, Uganda, Kenya, Sudan, Nigeria, and India. The time required to thresh the grain was found in most cases to be related to three factors: the structure of the plant; the degree of dryness of the heads; and the method of threshing used (beating being the fastest, the mortar and pestle the slowest). Average time spent per day to thresh grains in a related study in Senegal was 1–2 h.

In many countries grain is stored in the head and only threshed as required. The preference for method of storage varies with region and is related to sociocultural background and climate. For example, in Nigeria the Yorubas harvest the sorghum and carry it home for immediate storage. Only enough grain is taken out of storage and threshed to provide a 2–4 week supply. On the other hand, the Nupes, Gwaris, and Hausas of Nigeria thresh all the grain before they store it.

Some labour-saving methods for threshing have also been tried. In Nigeria, for example, motorized threshers were experimented with but they were found to produce more broken grains than the traditional methods. In this case, grain hardness, as related to method, ease, and efficiency of threshing, becomes one of the criteria for cultivar acceptance. Recently, in India, the heads have been spread on the roads so that the grains are removed by the tires of the vehicles that drive along the road. This method, while not recommended because of the traffic hazards, saves both time and labour because 2–4 ha of grain can be threshed in 1 day by a few people. Normally 25–35 labourers are required to thresh about one-

Tedious threshing practices discourage increased production of sorghum and millet.

half hectare. In the Sudan the large-scale farms use large mechanical combines to thresh the grain.

While the common practice is to store sorghum and millet on the head and thresh as needed, repeated storage tests in Senegal have shown that when properly dried and stored, the quality of threshed grains exceeds that of grains stored on the head. Unthreshed grains suffered greater losses due to insects and mould.

By considering some general guidelines when threshing it is possible to improve the yield and efficiency of the threshing process: (1) the heads should be threshed on mats, not on sand, gravel, or stones because this helps keep the grain clean and reduces the amount of winnowing required — the best method is to thresh on adobe or cement blocks; (2) the grain should have a maximum moisture content of 10–12% when threshed as this reduces the possibility of mould development during storage; (3) vitreous flinty not starchy types should be threshed to reduce the number of broken kernels being stored; and (4) if possible, grains should be threshed early to reduce field exposure to birds, rats, etc. (after making sure the moisture content is low enough).

Storage

Proper storage is essential if the work put into growing, harvesting, and drying the grain is to be rewarded with a supply of food throughout the year. The principles involved in good storage of sorghum and millet are similar to those required for maize and rice. To ensure proper grain storage three variables must

be controlled: moisture, temperature, and oxygen. These variables can be controlled by efficient grain drying, proper construction of the storage bin, and the observance of certain precautions concerning the methods of storage.

If grain loss during storage is to be reduced, proper sanitation and management practices are essential: (1) the grain must be dried and cleaned to eliminate mould, insects, and bird or rodent droppings; (2) the grain should be kept as dry and cool as possible; (3) whole grains should be stored, and broken grains, which are more susceptible to weevil damage, avoided; and (4) protection from fire and theft is needed.

Construction of the storage bin — its size and shape, the wall material, the amount of shading built into the design — affects the environment within the container and therefore the success of storage. In general, the larger the bin the more successful the storage because the bulk of the grain is insulated from changes in outside conditions to a greater extent (provided the grain is cool when the bin is filled). The bin should be about the same height as width because this shape also promotes better insulation. If the width is much larger than the height, temperature variations are larger and condensation problems can lead to increases in moisture content, and subsequent grain losses due to mould. The type of construction of the bin wall also influences storage conditions. With an open weave the outside temperature and the temperature of the grain are almost the same, especially when the grain is stored on the head. This storage method is well-suited for very humid climates as grain that is slightly damp can dry. Solid-wall bins are not as quickly affected by outside air temperature and thus are able to reduce temperature variations in the grain. The design of the roof used on the bin can also be used to advantage to shade the walls. When a large roof with an overhang is used the fluctuations in grain temperature with day and night temperature are reduced because the shade on the bin keeps the temperature down. Steel storage bins are generally not recommended (unless the grain is very dry) because they are susceptible to temperature variation and thus promote condensation and subsequent mould problems.

The method of filling a bin also affects storage success. The bins should be filled as early in the day as possible when the air temperature and humidity are lowest (at 70% relative humidity the grain would have a moisture content of 15%, which would lead to mould development in sorghum). The method of filling the bin also has an influence on the control of insects. Because insects are generally found on the top of the stored grain in the air space, limiting the amount of air in the storage container will help to control insects. The grain should therefore be packed as tightly as possible, eliminating any free air by mixing the grain with sand or ash, and stored dry and threshed. Millet stored in the head may be somewhat advantageous because glumes on the heads may irritate the bugs. However, studies in Senegal have indicated that properly dried and threshed sorghum and millet stored admixed with 30% sand incur fewer losses than unthreshed, on the head, traditional storage controls. It is also a good idea to store only whole grains because the hard seed coat helps protect the endosperm from insect attack to some extent.

Moulds are generally found at the bottom of the bin, i.e. where it is cool, dark, and damp. Control measures for moulds also involve keeping the grain as dry as possible, at a constant temperature, and limiting the amount of free airspace. In addition to drying the grain, sunlight destroys any existing moulds.

Control of fire and rodents can be effected by keeping tall grass cut within 6–7 m of the bin; water and birds can be excluded by a good roof, which can also

provide shade to the sides of the bin; but protection from theft must rely on sociological methods.

Storage facilities in the various countries vary from small traditional containers to silos on large government farms. Traditional granaries made from plant materials like bamboo, stalks, bark, branches, and mud are used in most of the countries. These granaries may be on the ground or raised off the ground on platforms or stilts. They may have open woven walls or solid walls. Smaller amounts for short-term storage are often kept in clay pots, calabashes, cloth or sisal bags, and baskets. Special plants with insecticide properties to control insects, and ash, sand, or mud to omit air may be used. In Kenya most of the sorghum and millet, often mixed with wood ash, is stored as grain in clay pots ranging in size from 3 to 20 litres.

In Nigeria, most of the sorghum and millet is stored as unthreshed heads in solid-wall dried-earth *rumbus* using either of two procedures, *jefe* or *kimshe*. *Jefe* is used for short-term storage and the bundles of sorghum and millet are merely thrown into the *rumbu* and arranged in layers. For storage of 3–6 years, the *kimshe* method is used. Here the bundles are dismantled as they are put in the *rumbu* and are then packed in layers. Some farmers spread the leaves of *gwander daji (Anona senegalensis)* on the bottom of the *rumbu* and between each layer of grain to keep the grain in good condition. When the *rumbu* is full the mouth is sealed with clay. Because of the tighter packing in the *kimshe* system more bundles can be stored with this system. No local insecticides are used on the grain but sometimes the stems of a fleshy, juicy xerophytic plant *(tuniya)* are used for protection against rodents. These stems can also be included in the foundation when the *rumbu* is built, or can be placed on the floor.

Flour quality depends on the methods used to produce, store, and process grain.

A variety of other methods are also used. In Uganda, sorghum is threshed and stored in gunny sacks that are sometimes treated with insecticides; whereas, millet is stored in the head. Along with other methods, underground stores or pits are used in India and Sudan. Clay blocks have been used to increase the quality and yield of grain stored underground in India. Square or round pits, called *matmoras* in Sudan, holding 2–5 tonnes of grain are traditionally used. On large farms in many of the countries, grain is stored in warehouses ventilated by small windows, in the open in sacks on platforms covered with canvas, or in large silos.

To the farmer, grain deterioration and the period for which the grain can be stored are a function of good construction and management. But, though sorghum and millet can be stored in the *rumbu* for up to 6 years without deterioration, in most countries they are usually only stored until the new crop is harvested.

The traditional systems found in these countries incorporate many of the ideas and precautions for successful storage that were discussed earlier. By modification and careful management, traditional systems might be used to guarantee regular supplies of grain throughout the year. The combination of traditional systems with some modern storage ideas may not only be able to extend the period of successful storage but may at the same time be able to improve the quality of the stored product.

Milling

Although the use of sorghum and millet for human consumption is widespread, the technology for processing these cereals is far from adequate. Traditional methods in all countries involve very time-consuming hard work, and although small-scale grinders have been introduced in some areas, mechanical production of flour is limited because of a lack of dehulling technology for these grains.

If there is time in the traditional process, grains are dampened and dehulled before being ground into flour. Dehulling is done by hand pounding and, depending on variety, requires 3.5–5.5 min/kg of sorghum and 6–22 min/kg of millet (estimated in India).

Home and village grinding mills are then used to pound or grind the grain into flour. Stone mills consisting of a small flat stone on a larger rectangular stone or two round mill stones, one rotated by a wooden handle, are used in many homes. Mortars in the form of wood, stone, or holes in the ground, and wooden pestles (some with metal rings on the tip) are used as well. Diesel and less frequently water-powered hammer or plate mills are located in most villages.

Sorghum being a larger grain is more easily dehulled than millet. For this reason, in most countries millet is less frequently dehulled. Either wet or dry grinding, depending on the custom, region, and end use of the flour, is practiced. Generally the dry ground flour may be stored several weeks and the wet ground paste,often used slightly fermented, 3–4 days. The flour or paste may be prepared from whole, dehulled, roasted, germinated, fermented, soaked, or dry grains. Some of these methods affect the flavour, nutritional value, and utilization properties of the flour or paste.

Flour particle size may vary from coarse to fine depending mainly upon intended use of the flour but also on grain hardness, the milling methods, and the presence or absence of hull portions.

In rural Kenya, some traditional milling is still done with a grindstone, but in other areas where diesel-operated hammer mills have been introduced sorghum and millet are ground alongside maize. The main reason for the switch is the greatly reduced processing time with the mechanical grinders (a few moments versus 20–30 minutes to grind enough flour for a family of six). Unless the grain is dehulled by hand prior to grinding the resulting flour is coarse in texture and contains all the bran, some of which is discarded at home after sifting.

A very similar pattern exists in Tanzania, with hand grinding being done only when there is no mechanical grinder close by or the housewife lacks the money to pay the grinding costs. Dehulled cracked grain and flour are the common home-milled products.

In the Sudan two types of grinding are practiced: dry (the most common) and wet. Wet grinding is done by rubbing the soaked grain between two stones until a fine paste is produced. This paste is used either directly or left to ferment. For dry grinding, small electric or diesel stone mills are used. The product in this case is a whole-meal flour that may be coarse or very fine.

In India there is a strong preference for freshly dehulled grains and milled flour processed by hand. Sorghum is usually dehulled daily in a mortar and pestle in India, using a generous supply of water in the final stages to wash away the loosened hull portion. The grains may be washed 3–4 times, often removing the germ and some flour with the hulls. The water is given to domestic animals and a dense water (i.e. containing a good portion of hulls and grain fragments) is desired. If the sorghum is to be milled into flour for *roti* (a flat unleavened bread), the grain is simply pounded or ground whole without prior dehulling. The flour is coarse due to the hull portions.

Millet in India is dehulled in a *chakki* by lightly grinding and winnowing the dry grain. After winnowing, it is futher dehulled by pounding in a stone mortar to remove the undercoat, washed extensively as done for sorghum, and milled into flour. Millet flour used in India is much finer than sorghum flour because it is generally made using dehulled grains.

The method of milling chosen in Uganda depends on the use of the milled product. Sorghum or millet used for beer, for example, is coarsely ground. Sometimes a mortar is used, but in Buganda the grain is crushed on a rough wooden surface using a piece of broken pot, which is faster than using a mortar. The grain is either roasted or germinated before grinding. When either sorghum or millet is used for food, it must first be dehulled by hand pounding the dampened grain and then finely ground using a stone. Trading centres, which offer mechanical grinding services for a fee, are now supplementing traditional methods.

Three different methods are commonly used in Nigeria to mill sorghum and millet: grinding on a stone; pounding in mortars; and processing with machine grinders. Although machine processing is the fastest, as in India, the product from the mortar is preferred because the flour is finer and often whiter, because it contains less bran.

Broken grains are used by Nigerians to prepare a paste for porridge. Both sorghum and millet are usually dehulled and the flour is produced using a wet or so-called dry method. For the wet process the grain is soaked in water 1–2 days, milled into a paste, and strained to remove the bran from the filtered starch portion. This may be left overnight to ferment slightly before using it. For the so-called dry method, grain is first soaked then pounded to loosen the hulls. The resulting product is dried, the hulls are removed by winnowing, and the dry grain is

ground into flour. A new dry mechanical process has been introduced in which the hulls are removed mechanically prior to grinding in a hammer or plate mill. The resulting dry flour when mixed with water can be left to ferment overnight as is done with the wet-milled paste for use in similar products.

Traditional methods for sorghum and millet processing are similar in all countries, but today in the sorghum and millet eating areas of the world, people are taking their grains to mechanical grinders in the village. These are generally hammer or plate grinders that are used to grind the grains into flour. Usually they do not have equipment to dehull the grains. With increasing demands being put on time, people either mill the grain without prior dehulling by hand, or less frequently continue to dehull the grain by the tedious mortar and pestle method. In some areas, people are gradually moving away from these grains because of this. Due to the higher hull content, grains milled without prior dehulling produce a less desirable product in terms of digestibility, colour, and texture.

Because processing methods are already changing, it is no longer a question of whether or not one should mechanically process these grains but rather what is the best way to do it. Dry mills, designed specifically for sorghum and millet, that dehull and grind the grains into flour can improve convenience, acceptability, and shelf life. Mechanically processed sorghum and millet flour decreases the tedious hand processing time, the flour moisture content, and the amount of hull. This in turn improves the digestibility, colour, convenience, and texture of the end product, making the flour more easily available to consumers.

This raises several questions regarding the quality of mechanically produced flour. Colour is one of the major criteria determining the end use of a particular sorghum or millet. Lighter varieties, which produce lighter flours using the hand process, are used for porridge, bread, and other flour-based products. Darker varieties, which by the hand process produce darker flour and the accompanying bitter taste of these colours, are fermented and used for beer and other fermented beverages. Traditionally some of these grains have been bleached in acid solutions, like tamarind water or fermented water from rice washing, to improve the colour, and then wet milled into a flour paste.

Nutrients are lost during dehulling, a process that involves removal of the pericarp layer and parts of the germ. In one Nigerian study of hand milling, kernel losses of up to 29% of the dry weight were recorded. As floury grains have a soft and easily fractured aleuron layer losses are often higher than those for flinty grains.

Using a machine process, flour can be consistently produced at higher extraction rates than those commonly resulting from a hand process. Mechanical dehulling also makes it possible to produce a white flour using red sorghums and blue-green millet varieties by lowering the extraction rates and removing more of the bran and subcoat. While this produces a very colour-acceptable flour that can be used in cooked products, the nutritional quality of the products is not the same as that of products made from flours milled at a higher extraction rate.

In comparative tests done at the Prairie Regional Laboratory, Saskatoon, using sorghum and millet, the food value was typically decreased by both hand and mechanical processing methods and generally the nutrient losses were more pronounced in the mechanical method. At similar extraction rates, flour derived from mechanically processed grain contained on average only slightly less protein than a traditionally prepared flour. Crude-fibre intake was comparable in the case of sorghum and 20–25% less when millets were mechanically milled. With children and infants, a lower fibre content is preferable.

In many cases, slight reductions in fibre and protein content become negligible when considering the other components in the typical diet. Commonly sorghum and millet are consumed with other foods such as legumes, other cereals, and/or vegetables. Additionally, these fibre and protein reductions may be offset by increases in total sorghum and millet consumption. Experience in a number of countries has shown that when a more convenient and comparable sorghum flour is available the consumption of this crop increases.

Thus, to use the words of one of the workshop participants, "instead of running away from these traditional products, we should be encouraging their use as quality foods that are as good or maybe even better than some of the foods people are presently substituting for them."

Enrichment and Marketing

Traditionally, products are easily enriched by germination or fermentation at no added cost. In manual dehulling, grains are often moistened and at times intentionally left to sprout before milling into flour. The flour is frequently mixed with water and allowed to ferment before cooking. Both of these treatments can improve the nutritional value of the end product.

In India, water collected while washing the pounded (dehulled) sorghum is stored, fermented, and used for boiling rice or for a beverage. Being acidic, the water is said to improve the keeping quality of cooked rice, improve the nutritional value of the rice, and as well impart a desired flavour.

In the Sudan, careful studies have been undertaken at the Faculty of Agriculture, University of Khartoum, to assess the nutritional, biochemical, and microbiological changes occurring during the preparation of *kisra,* a popular bread made using a fermented batter. Studies were made using three sorghum varieties with determinations made for each on the grain, the fermenting dough (after 3, 6, and 12 h), and the cooked product.

During fermentation, number of calories dropped, protein content increased up to the twelfth hour, nonprotein nitrogen increased, total sugar decreased and then increased, and the thiamine, riboflavin, and niacin contents increased in comparison to the whole-grain starting values. After baking, protein content was slightly reduced, fibre content was increased (due to the presence of micro-organisms), thiamine was about the same, riboflavin content slightly less, and niacin content was greater than the amount originally present in the grain. Overall, the fermentation resulted in products enriched through the synthesis of some B vitamins, the dextrinization of the fibre, and the development of flavour.

Studies of this nature will go a long way toward establishing the best methods for enrichment by fermentation, the optimum conditions for successful enrichment and the types of changes to be anticipated during the process.

Beliefs about the nutritional shortcomings of sorghum and millet at times make it difficult to use these crops. Composite flours of 85% germinated, dehulled sorghum and 15% black gram (and/or other legumes) supplemented with fruits and vegetables have been used in south India as the basis for a day-care centre feeding program. At first the mothers resisted the idea of feeding sorghum to their children. Following this, the sorghum and legume flour was presented in a variety of biscuit forms and subsequently accepted.

Commercially produced biscuits available in packages are a high status food that is sometimes purchased when serving guests. Thus, when the sorghum was

presented as a biscuit or in other snack forms, the mothers were willing to have their children eat it. With the benefits of the improved diet and the health care at the day-care centre, the children, malnourished at the time the study began, soon recovered their growth and for the remaining 2 years of the study demonstrated growth curves up to the recommended norms for Indian children. This study indicates the nutritional value of sorghum when the fibre content is reduced by dehulling.

A limited number of sorghum and millet products are marketed on a commercial basis. Flour, beer, germinated grains, bread, and snacks made at home, are frequently sold at small daily or biweekly markets. Most of these items are perishable and can only be stored for 1–5 days depending on the product. The recipes and methods are very skill-oriented, thus the quality of a particular product can vary from seller to seller and from day to day even with the same seller. In Nigeria, *fura,* a snack food, is often commercially prepared in a ready-to-eat form. It is a daily food processing task characterized by a small-scale, simple technology, the use of ordinary household equipment, and a strong orientation toward the consumer. *Uji,* a thin porridge, exists on a small-scale commercial basis in street kiosks of major towns in Kenya. The small-scale nature of traditional processing such as this provides an advantage in that investment is fixed, working capital is low, and by-products are usually geared to local requirements.

Aside from these home food-processing industries, a limited number of products (mainly beer) are sold by small firms. In Tanzania *ohibuku* beer is produced from sorghum; whereas, in Uganda, millet is preferred for commercial brewing. In Kenya, thought has been given to the marketing of a fortified thin porridge, like *uji,* similar to products being marketed elsewhere in Africa.

In Sudan, trials have been made by the National Research Council and the Food Research Centre at Khartoum to improve the processing and quality of *kisra.* Commercially prepared *kisra* is more expensive than bread due to the tedious process involved. A factory producing *kisra* packed in polyethylene bags was developed and is being improved. As well, a pilot mill at the Food Research Centre is producing mechanically dehulled and ground flour. This light-coloured, finely ground, dry-milled flour, produced from a red variety of sorghum normally used for brewing, is a popular ingredient for preparing *kisra,* local snacks, bread, and pastries. The flour, marketed as "improved flour" is sold at one-sixth the cost of the high status food, rice. It is produced at an 80–90% extraction rate, has an average protein content of 11%, and is sold in 5, 10, and 15 kg bags. Even though people are not used to the resulting finer milled product, it is very popular because it keeps better and compares well with the traditional wet-milled product. To begin market promotion for this product, a luncheon was held at one of the most prestigious hotels in Khartoum. Breads, snacks, sweets, and pastries made using sorghum flour were served at the luncheon to honoured government officials.

Recipes

Both traditional and new recipes using sorghum and millet have been developed in a number of countries. In Kenya, the University of Nairobi Home Economics Department has published a sorghum cookbook containing traditional and adapted recipes including: soups, main dishes, breads and cakes, desserts, and miscellaneous dishes. Home Economics students at the Bukalasa Agricultural College in Uganda have worked with several millet recipes for breads and other products. In Dar es Salaam, the Tanzanian Food and Nutrition Centre has developed a number of sorghum recipes and printed them in Swahili as a pamphlet. Sorghum and millet recipes have also been prepared in Nigeria by the Home Economics Section of Ahmadu Bello University, Samaru, Zaria. These include both traditional and nontraditional main dishes and snacks.

In the pilot bakery at the Food Research Centre in Khartoum, Sudan, several sorghum breads and pastries have been developed and their acceptability and marketability are now being tested. The College of Home Science, Andhra Pradesh Agricultural University in Hyderabad, India, has as well been engaged in extensive sorghum and millet food studies. Several recipes for preschoolers have been developed and clinically tested for acceptability and nutritional adequacy. These recipes have been compiled in a pamphlet. The Ethiopian Nutrition Institute in Addis Ababa has also prepared a pamphlet of sorghum recipes printed in Amharic.

Recipes for several of these traditional and new sorghum and millet foods were demonstrated at the workshop. Because of the similarity and skill-oriented nature of these recipes, not all have been included in this publication. Instead, example recipes have been drafted and are accompanied by the variations typically found in each country. At least one example recipe from each of the participating countries is included.

Expanding the utilization of sorghum and millet would go a long way toward providing an ever-increasing population with food, and of course, they also have the built-in advantage of thriving in areas of limited rainfall where other cereals often fail.

Using simple, if somewhat time-consuming methods, these two cereals can be processed into two main products: a dehulled whole kernel and a ground flour. From these, many traditional recipes can be prepared; recipes that are in fact similar from country to country. Dehulled whole or cracked grain recipes are not as numerous as recipes based on flours, pastes, or malts. Foods derived from sorghum and millet flours can be divided into porridges, breads, miscellaneous snacks, and beverages. The key foods (i.e. foods served at least once a day) in all of the countries are either whole grains, stiff porridges, or breads. In some cases these foods are prepared from a variety of grains including maize, wheat, and rice. In rural areas, however, the traditional sorghum and millet staples are customarily used. A list by country of key foods made from sorghum and millet is given in Table 2.

Table 2. Some important foods prepared from sorghum and millet in the various countries.

Product name	Product type	Country
Key foods		
kisra	leavened batter bread	Sudan
injera	leavened batter bread	Ethiopia
roti	unleavened flat bread	India
ugali	stiff porridge	Kenya, Tanzania, Uganda
tuwo	stiff porridge	Nigeria
Other foods and beverages		
uji	thin porridge	Kenya, Tanzania
fura	snack	Nigeria
busaa	beer	Kenya
	beer	Uganda
pito	beer	Nigeria
pombe	beer	Tanzania
marisa	beer	Ethiopia, Sudan
hulu-mur, abrey, huswa	nonalcoholic beverage	Sudan

In West Africa, particularly Senegal, a steamed agglomerated product called *couscous* is a key food. Generally, it is made using millet flour and liquid is gradually added to the flour while stirring to form small beads or agglomerates. These may be either steamed and served or dried and steamed later.

Sorghum and millet in the form of beverages are also an important dietary constituent. These beverages include nonalcoholic products, beers, and distilled products. In a number of areas priority for sorghum and millet production is often given to their good brewing properties. Some of these beers are unfiltered, with the germinated grain fragments and living microorganisms providing nutritional benefits not available in commercially produced filtered beers.

Miscellaneous snacks, comprised of noncooked, fried, deep fried, boiled, or steamed batters or doughs, even when consumed daily, are of secondary importance. These foods are not considered as key foods or staples, because less sorghum and millet is used to prepare these foods.

Traditionally, foods prepared at home are based on skill-oriented recipes. As such the amounts are often estimated by hand, bowl, tin, or other convenient measures. The following recipes include various types of measures ranging from portions to weights. Weight measures of course are preferable as they provide greater accuracy and recipe reliability.

It is recommended that similar recipes be used to develop standardized methods (utilization tests) for preparing and evaluating key sorghum and millet foods. The following recipes have been divided by product types into seven categories each including a general description of the category, the criteria of acceptability, one or more example recipes, variations for the recipes, and a list of the names of similar products in other countries. Because there are no

standardized spellings for many of the local names, they have been given in the form most commonly found. Cooking times for the products may also vary depending on altitude. The products are: whole or cracked grains; thin porridges; stiff porridges; leavened batter breads; unleavened flat breads; miscellaneous snacks; and beverages.

Whole or Cracked Grains

Dehulled sorghum or millet is served as a whole or cracked grain in a number of countries (Table 3). As a whole dehulled grain it may be steamed by itself and served as rice or cooked with whole pulses and served as a mixed dish. Broken kernels are sometimes used for the "rice-like" product as well as for other products made from the cracked grains. All three products may be consumed with the main meal as often as once a day. Dehulled grain is also ground into flour for use in other products.

Standard Description of Quality

For the rice-like product, fluffy, uniformly white, distinct, individual, sweet kernels are desired. A sticky product with poorly defined kernels is not desired. In India one sorghum variety was not accepted because a red spot near the germ could not be removed in processing and the colour spread during cooking and gave

Table 3. Typical whole or cracked-grain products made from sorghum and millet.

Local name	Description	Country
acha (acha patten)	grains steamed whole	Nigeria
bakri	sorghum boiled with sugar	India
burabusko	steamed millet	Nigeria
dafa duka	boiled grain	Nigeria
dahuwa	boiled grain	Nigeria
ewa	boiled grain	Nigeria
garin acha	mixture of fermented whole grain, sugar or honey	Nigeria
kande	boiled cracked sorghum with legumes	Tanzania
khichri	whole cooked millet and gram	India
khir	dehulled whole rice and millet cooked in milk	India
ly	parched millet and rice sweetened and shaped into balls	India
mehri	rice and millet cooked in curd	India
mtama mu bufuke	cooked and mashed sorghum and pulse	Kenya
oka baba	boiled grain	Nigeria
paparia	fried, cracked grains that have been previously soaked, fermented, boiled, and dried	India
pate	mixed dish using cracked sorghum and millet	Nigeria
pearl dura	boiled dehulled sorghum	Sudan
sorghum "rice"	boiled dehulled sorghum	India

a pink product. Along with colour and texture, fodder quality and yield, and the density of the water resulting from the washing of dehulled grains are important criteria of quality in India. Both of these by-products are used as animal feed. Differences in dehulling time and yield were less critical.

Dehulled Cooked Grain

Ingredients
1 volume dehulled sorghum or millet
2 1/2–4 volumes of water (depending on variety and preferences)

Method
Boil or steam grain until tender (20–40 minutes)
Serve with meat or vegetable sauce or stew

Notes/Variations
India This is called sorghum or millet "rice." When sorghum is used, it is often soaked in the water overnight and cooked the following morning using the same water. Sometimes a fermentation occurs. The soaked grain is said to be whiter and keep longer than grains not soaked. This is perhaps due to the slight fermentation. Cooking time may be reduced by this soaking practice.

Sudan A similar product is made from pearled dura.

Whole or Cracked Sorghum (or Millet) with Whole Pulses

Ingredients
2 cups dehulled sorghum (whole or cracked)
1 cup pulse — beans, peas, etc (whole or split)
7 cups water

Method
Bring water to boil
Add pulse and cook until partially done
Add sorghum and continue boiling until tender
Season as desired

Notes/Variations
Tanzania *Kande* is usually made from sorghum. The grains may be soaked overnight to shorten the cooking time and cooked in the soaking water. Salt and other seasonings are added after cooking.

Kenya *Mtama mu bufuke* is made by cooking sorghum and green gram or cowpeas until very soft. They are then mashed and mixed with salt and mashed cooked sweet potato,

potato, banana, or cassava, and served with greens, lemon, or orange slices.

Nigeria *Dafa duka, ewa, dahuwa, oka baba* are prepared by cooking 1 cup sorghum (dehulled) with 1 1/2 cups beans until tender, and then adding 1/2 cup palm oil, 1 tsp groundnut pepper, 1 tsp salt, 1 small onion, and 2 Maggi cubes (optional). *Burabusko* is made in the same manner as *dafa duka* using whole millet that has not been dehulled.

Dehulled Cracked Grain

Ingredients
2 cups whole or dehulled sorghum or millet (ground coarsely)
1/2 cup spinach
1 large pepper (chopped)
3 medium tomatoes
1 medium locust bean cake
1/2 onion
Salt to taste

Method
Bring water to boil
Add pepper, tomato, bean cake, onion, and salt
When almost tender add the coarsely ground (i.e. cracked) grains
Cook for 8–10 minutes
Add spinach and cook another 2 minutes
Serve hot for lunch

Notes/Variations This recipe comes from Nigeria where it is called *pate*.

Flour

Sorghum and millet flour are used as an ingredient in recipes for thin and stiff porridge, leavened and unleavened bread, and boiled, steamed, popped, fried, and deep-fried batter and doughs (included in miscellaneous products). Additionally in a number of countries, flour from dehulled grains (sometimes roasted) is mixed with sesame, butter or honey, and spices and served as a noncooked snack.

Standard Description of Quality

Colour preferences for flour depend on the colour of locally available grains. There is generally a preference for lighter colours. Particle size varies from coarse to very fine depending on local practices and the end use of the flour.

Thin Porridge

In many countries a thin porridge is traditionally prepared from wet milled pastes or dry milled flour using either dehulled or nondehulled grains (Table 4). Millet, because of the smaller grain size is less frequently dehulled. Sometimes the grains are roasted, bleached in tamarind water, or germinated prior to dehulling and grinding into flour. Porridge may be fermented or nonfermented and is frequently served for breakfast or to new mothers and young children. Very similar products can be made with composite flours of sorghum/cassava, sorghum/millet, and sorghum/millet/cassava.

The texture of thin porridge varies depending on flour particle size, and often a combination of finely and coarsely ground flour is used. Flour agglomerations may be added to alter the texture of the porridge. The flavour as well may vary depending on whether it is fermented or not, and whether the flour was made from roasted or germinated grain. Seasonings, sugar, sesame, lemon, or sour milk also affect the flavour.

Standard Description of Quality

In general, a light colour, smooth, free-flowing creamy consistency, and bland to sour flavour and aroma are preferred depending on the region and process used. Colour preferences vary according to the colour of flour normally available in the region. Dark, lumpy, grainy, or watery products with a raw starch, bitter, rancid, or off-flavour (due to tannins in the hull or undercoat, or mould developed during storage) are not desired.

Uji (thin porridge)

Ingredients
1 cup sorghum or millet flour
3–4 cups water (adjusted to individual consistency preferences)
1 cup sour milk (water may be used instead)
2 tbsp sugar

Method
Mix flour with 1/2 cup water
Place in a covered container and let stand 24–48 hours in a warm place (for unfermented porridge this step is omitted)
Bring remaining water to boil and add the fermented flour
Cook 10–15 minutes until smooth and thick
Add sour milk, stir, and boil for 1–2 additional minutes (commonly an extra cup of water is added in step 3 and this step is omitted)
Sprinkle with sugar and serve hot for breakfast or lunch (serves 2–3)

Notes/Variations **Kenya** *Uji wa mtama* is often made with mixtures of 2 parts maize or cassava flour to 1 part of sorghum or millet flour. The hulls present in sorghum or millet flour impart the desired product colour. Millet is preferred.

Tanzania *Uji* is often seasoned with sugar, salt, milk, or lemon juice. A very finely milled white flour is used.

Uganda *Obungi bwa kalo* is made as above using about 4 cups of banana juice instead of the water and omitting the sour milk. Usually millet flour is used. *Obushera* is a thin porridge made from germinated grain. A malted coarsely ground sorghum flour (made by adding ash and water to the grain, germinating it overnight, washing off the ash, drying and grinding the grain) is often used. Porridge is frequently seasoned by adding a generous amount of sugar, orange juice or lemon juice, mashed banana, sesame paste, or milk. *Edi* is a nonfermented version of *obushera.*

India *Ambali* is made as above, but omitting the sour milk. Sometimes fermented rice washings *kali* are mixed with the cooking water. Leftover *ambali* is stored in cold water and later mixed to serve as a beverage.

Nigeria *Akamu, eko,* and *ogi* are thinner products made with 2 tbsp of sorghum or millet paste to 2 cups of water. *Koko* is similar to *uji* except a portion of the paste is formed into little balls and cooked in the boiling water before adding the rest of the paste and

continuing cooking. This gives the porridge a different texture. In addition, tamarind water, spices, and sugar are added. *(In some places koko may be the name of a quite different product, including a highly fermented beverage.)*

Sudan *Nasha* is fermented if sorghum is used, and it is served with sugar. If millet is used it may be either fermented or nonfermented and it is served with milk or honey.

Table 4. List of local names of traditional thin-porridge type dishes.

Local name	Description	Country
akamu	thin porridge	Nigeria
ambali	thin porridge	India
edi	thin porridge	Uganda
eko	thin porridge	Nigeria
kamu	thin porridge	Nigeria
koko	medium thin porridge with tiny balls of flour to add texture	Nigeria, Ghana
kunu zaki	medium thin porridge with tiny balls of flour to add texture	Nigeria
kunni tzamia	thin porridge	Nigeria
nasha	thin porridge	Sudan
obungi bwa kala	thin porridge	Uganda
obushera	thin porridge	Uganda
ogi	thin porridge from wet milled, fermented sorghum or millet	Nigeria, Ghana
puttu	sweet pudding or cooked finger millet flour mixed with crushed groundnuts, water, sugar, salt, and milk (optional)	India
rabri	millet fermented in curd and water	India
sorghum porridge	made with 4 parts of water to 1 part of flour	Sri Lanka
uji	thin porridge	Kenya, Tanzania

Stiff Porridge

A stiff porridge, which is frequently moulded or shaped, is cooked in all countries (Table 5). Stiff porridge is made in the same way as thin porridge but a greater proportion of flour is used. The same comments about the flour used for thin porridge apply here. In some countries a finely milled flour is used; whereas, in others a coarsely milled flour or a combination of coarse and fine flour is preferred. The flour may be made from roasted, germinated, fermented and/or dehulled grains. When cooked, stiff porridge should not spread when dropped into cold water, but rather should retain its shape. This is sometimes used as a test for doneness. When a coarsely ground flour is used, often a greater percentage of hulls are incorporated, and the colour and texture of the final product are altered. Stiff porridge is a key food served as freqently as 1–2 times/day. As was the case for thin porridge, stiff porridge may be made from a combination of sorghum and millet flour with cassava and in some cases, maize. Flavour varies depending on the seasonings and processes used.

Standard Description of Quality

The criteria for quality are the same as those for thin porridge, except with regard to consistency. Stiff porridge should be stiff enough to mould smooth without cracks. A product that sticks to one's fingers or the roof of one's mouth, or crumbles in the hand is generally not desired. The texture of sorghum or millet *ugali* (a stiff porridge) is similar to that for maize *ugali*.

Ugali (stiff porridge)

Ingredients
2–3 cups sorghum or millet flour
4–5 cups water

Method
Bring water to boil
Add flour while stirring to avoid lumps
Continue cooking until stiff (and the starch is hydrolyzed) — about 15–20 minutes depending on the altitude, quantity prepared, cultivar variety, and cooking temperature
Place on a flat plate and smooth the sides with a spoon to mould (sometimes *ugali* is served in a calabash)
Serve with a savoury dish, meat, or vegetable sauce or stew, green vegetables, etc (serves 2–3)

Notes/Variations To give a finer, less coarse texture and a lighter colour, cassava flour may be substituted for about one-quarter of the total flour in the basic recipe. To obtain a smoother product a portion of the water (before heating) is sometimes mixed with the flour and then this is added as a paste to the remaining water (which is boiling) as in step 2. In step 3, the heat may be reduced and the porridge left to cook several minutes. Then the *ugali* may be turned over and cooking continued on the other side. This may be repeated, for a total cooking time of 20 minutes.

Kenya The juice of two lemons may be added to the boiling water or the water may be replaced with milk and ghee for serving to honoured guests. Powdered milk (4–6 tbsp) may be added to give an enriched smooth white product.

Nigeria This product is called *tuwo.* Sorghum is the preferred grain and is finely ground. *Saino,* a related product, is made using cracked sorghum grain rather than sorghum flour. *Dalaki* is made using sorghum starch instead of flour. The starch is made by soaking cracked sorghum grains in water for 4 days, pounding them into a soft paste, adding water and straining to remove the bran, drying the sedimented starch, and repounding it into flour. *Kafa* or *eko tutu* is a slightly softer porridge that when cooked, is served wrapped in leaves. *Kunu zaki* is made from a sorghum flour paste. Sweet potato flour is added after the porridge is cooked. The product is left to ferment overnight before serving (note: the flour paste in this case is not fermented before cooking).

India *Sangati* is made using a mixture of finely and coarsely ground flour. If millet is used it is not possible to coarsely pound the grain due to the small grain size. In this case, rice brokens are first partially cooked and then the millet flour is added to complete the recipe. Sometimes the flour is cooked in germinated rice washings instead of water to enhance the flavour and keeping quality. In the summer it may be mixed with buttermilk and made into a somewhat thinner porridge. Leftover *sangati* is stored overnight in cold water, mixed the next day, and served as a beverage.

Table 5. List of local names of stiff porridges common to sorghum- and millet-producing areas.

Local name	Description	Country
aceda	—	Sudan
atap	—	Uganda
bensaab	made with beans, served with groundnut soup	Ghana
bogobe jwa ting	—	Botswana
dalaki	made from a finely milled flour	Nigeria
eko tutu	—	Nigeria
kafa	—	Nigeria
kalo	—	Uganda
karo	—	Uganda
kunu zaki	a stiff porridge	Nigeria
kwon	—	Uganda
nshima	sometimes mixed with cassava	Zambia
nuchu	stiff porridge from cracked or pounded sorghum, served with buttermilk and salt	India
saino	—	Nigeria
sangati	—	India
tô	—	Upper Volta
tuo (tuwo)	an unfermented porridge made from whole (not dehulled) grain	Nigeria
tuo zaafi	stiff porridge	Ghana
ugali	—	Kenya, Tanzania, Uganda

Uganda *Ugali* may be mixed with groundnut paste, sesame paste, banana, or sugar and served with boiled mangoes. The flour used may be part millet, part sorghum, and part cassava flour. Other names for *ugali*-type products include *teso, atap, karo, kwon,* and *kalo.*

Sudan A related product called *aceda* is made.

Tanzania *Ugali* is also the name for this product.

Unleavened Bread

Unleavened bread made from whole ground sorghum or millet and baked over the fire in a hot pan is another important sorghum and millet product (Table 6). The greatest portion of sorghum and millet in India is used to prepare an unleavened bread called *roti.*

Standard Description of Quality

Roti should be soft after baking and remain soft for 1 day. A thin, yellow to white dough is preferred and a dark, red-brown product is not desired.

Table 6. Unleavened and leavened breads prepared from sorghum and millet.

Local name	Description	Country
Unleavened		
chapati	pan-cooked, round, thin flat bread made from a mixture of flour	India
roti	flat bread	India
rotti	flat bread of flour, water, and coconut (optional)	Sri Lanka
waina	fried bread	Nigeria
Leavened		
gahlet	small, thick cakes	Upper Volta
hoppers	cooked thin batter of sorghum flour, coconut, salt, water, yeast, and coconut milk	Sri Lanka
injera	fermented pancake	Ethiopia
kisra	fermented thin sheet	Sudan
maasa	fried millet cakes made from fermented millet batter and cooked dehulled millet	Ghana
masa (maasa)	fermented sorghum batter baked in a pan with individual cup-like depressions	Nigeria
masa wana	small cakes	Nigeria
mugabi	yeast bread	Uganda
sinasin	leavened millet pancakes	Nigeria
thosai (similar to the *dosai* in India)	thin pancake of black mung bean paste, sorghum flour,coconut water, salt water, and yeast seasoned with coconut milk, onions, chili, curry leaves, turmeric, and mustard	Sri Lanka

Roti

Ingredients
flour (sorghum, millet, wheat, or maize)
water (hot or cold)
salt to taste
oil (optional)

Method
Mix flour, water, and salt to form a firm dough
Shape into balls
Flatten into thin circles using hands or a stone
Bake in a shallow pan turning once to cook on both sides
Spread a small amount of oil on the *roti* before removing it to serve (this is not a common practice)
Serve with a small amount of hot pickle, dahl, or vegetable sauces

Notes/Variations
Nigeria *Waina* is made from 2 cups of sorghum flour, 1 cup water, 2 tbsp hot pepper or spices, and one-half bottle groundnut oil. The ingredients are mixed to form a dough, cut into flat discs, and fried in hot oil.

Leavened Bread

Leavened bread is frequently made using wild yeasts naturally occurring in the flour. One type of bread is a thin batter cooked on a hot griddle. Other leavened breads, made from doughs, are similar to wheat breads and are baked for a longer time. Leavened batter breads are key foods in Sudan and Ethiopia (Table 6).

Standard Description of Quality

Though the criteria of quality vary from the batter breads, uniformly distributed "eyes," a slightly sour flavour, and a soft, thin slightly moist (30–50% moisture content) and flexible product is preferred. A brittle, dry, dark product is not desired. For dough breads a slightly moister product is accepted than for wheat bread.

Kisra

Ingredients

9 parts sorghum flour (white variety)
2 parts water
1 part starter (yeast inoculum from a previously fermented batch of *kisra* batter)

Method

Mix flour, starter, and enough water to form a paste in an earthenware container and let stand overnight (about 18 hours)
Thin dough to the consistency of a batter
Spread about 100 ml of batter on a hot iron plate using a rectangular spatula (15 × 5 cm) to form a very thin layer of batter
Bake for about 30 seconds
Remove using your fingers and stack, one on top of the other, on a tray or woven container (cover with a plastic sheet or tray to store for use that day or the following day)
Serve with a vegetable, legume, or meat stew, soup or sauce

Notes/Variations This recipe is from Sudan. *Kisra* is baked on a hot (150–160 °C) iron plate of varying sizes usually 80 × 50 × 0.3 cm. The plate is heated by a charcoal or wood fire. When wood is used the plate is raised on three large stones to allow the wood to burn. Using coal requires a container to hold the coal, and the plates rest on top. Fire temperature is adjusted by practice. Millet flour may be used as well, though this is not commonly done in Sudan.

Ethiopia The same type of batter is used to make a round product called *injera* (about 40 cm in diameter). It is baked on a round clay or metal griddle covered with a cone-shaped lid. The steam cooks the top surface while the griddle cooks the bottom surface. The recipe given here for *injera* may be used if no starter is available.

Injera

Ingredients
2 kg sorghum flour
20 cups tepid water
1 cup liquid yeast (made from 1 ounce dried yeast and 1 cup water)

Method
Sift flour and mix with 8 cups of water and yeast
Knead 15 minutes
Cover and let ferment in a nonmetallic container overnight in a warm place
Knead the following day
About 2 hours before baking, mix 4 cups of boiling water with 1/8 of the dough, stir constantly and cook for 10 minutes
Add this cooked mixture to the remaining dough and water and let rise another 2 hours
Mix well and pour 1/8 onto a preheated griddle to bake
Serve with a meat or vegetable stew, yields eight large *injera.*

Notes/Variations **Nigeria** A similar batter is mixed with onion, pepper, and salt before letting it ferment overnight to make *masa.* Less water is used, so a thicker batter is formed. The batter is fried in a pan having 6–10 cup-like depressions for frying the small individual hemispheres. The *masa* are fried in oil and are turned so they brown on each side.

Uganda *Mugabi* is a bread made from a dough of millet and wheat flour.

Home economists must evaluate the consumer-acceptance of new varieties.

Miscellaneous Snacks

In many countries, sorghum and millet batters and doughs are served in various forms as snacks (Table 7). They may be cooked in deep fat, pan fried, popped, boiled as dumplings, or wrapped in leaves and steamed. Some of the products are made from extruded or agglomerated flours and a few require no

Table 7. Miscellaneous sorghum and millet products.

Local name	Description	Country
barfi	fried snack: millet paste fried in ghee seasoned with salt or sugar	India
besi	fried snack: fried and milled millet mixed with pepper, milled groundnuts and refried, served with sugar, water, or milk	Ghana
chindanda (luvale) "Africa bread"	stiff dough steamed in leaves	Zambia
dakuwa	noncooked snack	Nigeria
dambu	steamed dumpling	Nigeria
danwake	dumplings prepared from sorghum and cowpea flour	Nigeria
fate fate	dumpling	Nigeria
fulla, fula, fura	pounded and reshaped steamed dumplings	Ghana, Upper Volta
furah	pounded and reshaped steamed dumplings	Nigeria
gaibalin	pounded and reshaped steamed dumplings	Nigeria
gauda	leaf-wrapped steamed porridge	Nigeria
halape	steamed balls of cooked finger-millet flour (roasted), jaggery, coconut, and salt	Sri Lanka
hankara kanzo	dumpling	Nigeria
hura	see *fulla*	Nigeria
kadi	boiling cracked rice mixed with millet flour and salt	India
kanji	as above but stored overnight in salt and water before serving	India
kesari-aluna	sorghum sweet: roast 2 parts sorghum flour in ghee until crisp, add 1 part water or milk, sugar, and salt water. Cook, pour on plate, cool, cut	Sri Lanka
kharadya	fried dough cakes	India
kurodya	fried, extruded dough, similar to spaghetti in shape	India
lingende	dough shaped like cake and steamed without leaves	Zambia
maikya	deep-fried batter snack	Nigeria
pittoo	steamed agglomerations of flour mixed with coconut, salt, and water, a *couscous*-like product	Sri Lanka
popped sorghum	—	Tanzania
stringhoppers	an extruded steamed flour or a dough of roasted flour	Sri Lanka
thalapa	small pieces of a cooked paste served with gravy, sugar, jaggery or treacle mixed with coconut or milk	Sri Lanka
tsatsapa	deep-fried steamed batter	Nigeria
tubani	deep-fried steamed batter	Nigeria
tuwon katirara	dumpling	Nigeria
waina	sorghum and rice deep-fried snack	Nigeria
yer yau	deep-fried snack	Nigeria

cooking. These foods in general make up a less significant portion of total sorghum and millet consumption. Flavours vary from sweet to salty and spicy according to additional ingredients used (for example, sugar, honey, salt, onions, garlic, red pepper).

Standard Description of Quality

The shapes, textures, and seasonings of these products are markedly different, consequently there is little common ground for developing common standards of quality.

Gauda or Tubani

Ingredients
2 cups sorghum or millet flour
1 cup water
Some leaves for wrapping (prewashed)

Method
Mix flour with water to form a thick batter
Using a ladle pour a little batter on to a leaf
Wrap the leaves gently over the thick batter to seal
Drop in hot water and steam until cooked (30–40 min depending on size)
Serve with stew or soup for lunch or as a snack

Notes/Variations
This recipe is from Nigeria.

Fura

Ingredients
4 cups millet or sorghum flour (sifted)
2 tsp *yaji* or hot spices
6 cups water (for boiling)
2 cups *nono,* yogurt, or sour milk

Method
Mix flour, water, and spices
Shape into small round balls (2–3 cm)
Drop into boiling water and cook for 30 minutes
Pound cooked balls with water and spices until a smooth, slightly elastic, cohesive lump is formed
Reshape into small balls, using flour on a board and rolling by hand
Serve as is or with yogurt, sour milk, or *nono* as a snack (may be broken up and mixed to serve as a beverage)

Notes/Variations
This recipe is from Nigeria. *Fura* is perhaps the single largest selling ready-to-eat food product sold in northern Nigerian villages.

Nigeria *Danwake* is a firmer version of the cooked product resulting from step 3 of the recipe. It is served mixed with spices and groundnut oil. *Gaibalin* is made by recooking the balls in step 5, pounding the result, and mixing it with sour milk or *nono* to serve. *Tuwon katirara* is like *danwake* except that rock salt is added. Potash, added to the water, helps bind the balls together. *Hankare kanzo* is the name for a similar product cooked in a pot of soup rather than in water. This soup (called *yakuwa*) contains meat and is a delicacy. *Dambu* is a dumpling made from cracked grain and water. This is seasoned with sugar and butter or groundnut oil. *Fate fate* is like *dambu* but locust bean cakes and vegetables are added.

Popped Sorghum

Ingredients Sorghum grain (only certain varieties are used)

Method
Heat sorghum in a covered pan, moving back and forth over the fire
When popped, serve as a snack as is, *or*
Pound into a powdery product and mix with butter, honey, etc.
Shape into balls and serve as a snack

Notes/Variations The product in step 2 is often served in Tanzania; whereas, the step 4 product has been introduced in India.

Yer Yau (deep-fried batter)

Ingredients
1/2 bottle groundnut oil
1 cup sorghum flour
1/2 cup bean flour
3 tsp dried ground *kubewa*
1 1/2 tsp ground red pepper
1 1/2 tsp salt
1 1/2 cups water

Method
Sift sorghum and bean flour together
Add the ground *kubewa,* salt, and pepper
Mix well with water to a thin consistency
Fry in deep fat, and turn to brown on both sides
Serve as a snack

Notes/Variations This recipe and the first variation are from Nigeria. *Tsatsapa* is a similar product made with sorghum flour, water, and spices. It is extruded through a ladle (*ludayi*) having several holes, using a circular motion.

Sudan *Sham dates* are a deep-fried sweet snack made from 200 g sorghum flour, 300 g boiling water, 1 egg, 15 g fat, and 6 g salt. The warm water gives a better product. This mixture is extruded through a cookie press into the oil and deep fried.

Maikya (noncooked snack)

Ingredients
1 cup sorghum or millet flour (dry roasted in a hot pot)
1 cup ground rice (dry roasted in a hot pot) or groundnut paste
2 cups honey

Method
Boil honey and mix with flour
Knead and form into small balls
Serve as a snack

Notes/Variations This recipe and the first variation are from Nigeria. *Dakuwa* is a similar product made from roasted sorghum and tiger nuts *aya (Cyperus esculentus)* pounded into a fine powder. Instead of honey, sugar, spices, and salt are added and the dough is shaped into small balls and sold as cookies that are often served with *akamu* porridge.

Uganda Threshed sorghum, beaten and mixed with sesame is served as a snack.

Beverages

Unfermented beverages, beer, and distilled drinks are often made using the darker sorghum and millet varieties (Table 8). In Nigeria and Sudan unfermented beverages are made using sorghum. To make beer, the grain is germinated, dried, pounded into flour, and mixed with water to ferment. Sprouted millet is also used with sorghum flour to make beer. Wood ash is added in Uganda when making beer. Spices, leaves, or honey may be used as flavour enhancers, or a smoked flavour may be obtained by lightly burning the grain or dough. After cooking, the dough is pounded and added to the brew.

Some beers are filtered before serving, others while they are being consumed using long straws with woven filter tips (as in Uganda). Beers are also served with the solids left in suspension like the *busaa* and *marisa* of Kenya and Sudan. These beers often have greater nutritional benefits because of the presence of the sprouted and fermented grain solids.

Although a number of distilled beverages are also made from sorghum and millet, little information regarding these was provided at the workshop.

Standard Description of Quality

No descriptions of quality were drafted for these products. In general the beers tasted slightly sour and varied in colour from white to yellow if filtered.

Unfiltered beers made from undehulled grains were brown to brown gray in colour, and were cloudy, even suspensions that did not separate into layers.

Table 8. List of local names of beverages made from sorghum and millet.

Local name	Description	Country
Beer		
ajon	—	Uganda
amaarwa	—	Uganda
bojalwa	—	Botswana
burukutu	—	Nigeria
busaa	—	Kenya, Uganda
chimela	sorghum or millet malt for 7-day beer	Zambia
chipumu	beer served with solids	Zambia
dohlou	—	Upper Volta
embush	—	Ethiopia
itamba (itimba)	a beer starter	Zambia
katata	maize beer made using a finger millet starter *(itamba)*	Zambia
kongo	—	Uganda
kwete	millet and maize beer	Uganda
marisa	—	Ethiopia, Sudan
marwa	—	Uganda
munkoye	strained beer prepared from *munkoyo (Rhynchosia insignis)* and millet malt	Zambia
pito	beer served warm	Ghana, Nigeria
pombe	—	Tanzania
omukimba	—	Uganda
omulamba	—	Uganda
omwenge omuganda	banana beer	Uganda
seven-day beer	made using millet or sorghum malt	Zambia
sibamu	beer made using *chimela* (see above)	Zambia
sikokijana	quick brewed beer made using *chimela*	Zambia
sipesu	variation of seven-day beer	Zambia
talla	—	Ethiopia
umbugug	—	Sudan
yarobu kunyu	—	Nigeria
Nonalcoholic		
abrey	white beverage	Sudan
hulu-mur	red beverage	Sudan
huswa	—	Sudan
Whiskey		
araki	—	Ethiopia, Sudan
kachasu	—	Zambia
warangi	—	Uganda

Hulu–mur (nonalcoholic beverage)

Ingredients
2000 g flour (whole meal)
1000 g malted sorghum flour (red Feterita variety)
6000 ml water (more added before cooking to thin batter)
100–200 g spices (equal amounts of pepper, ginger, and cinnamon, plus a little cardamon)

Method
Mix malted sorghum flour and whole meal with water to form a fermented dough
Add spices to improve flavour then restart fermentation
Thin batter and bake until dry and brown as for *kisra*
Crumble into flakes and soak in water for 10–30 minutes
Strain, add sugar, and serve as a beverage

Notes/Variations
Hulu–mur, meaning sweet-stringent, is a nonalcoholic beverage served in Sudan during the fasting month (Ramadhan). The dry flakes resulting from step 3 may be stored for several weeks and used when desired. After soaking and straining, the flake residue is used as an animal feed.

Abrey, another nonalcoholic Sudanese beverage, is made using white sorghum flour (Mayo variety). The flour and water are left to ferment for 3–5 days before straining to remove the bran, adding the spices, and baking like *kisra* into very thin flakes. It is served with sugar and ice without prior straining. It is a white beverage with a slightly sour taste, which is served during the fasting month. In urban areas, surplus flakes are soaked and served year round to guests. Unlike *hulu–mur,* no malting is involved and the product is not strained.

Huswa is another nonalcoholic Sudanese sorghum beverage made from malted sorghum flour. It has a sweet pleasant flavour and is stored in the form of balls. In this case, the flour and water mixture is cooked in fat until brown and left to ferment by soaking it in water for 1 day.

Marisa (beer made without sprouted grain)

Ingredients
Sorghum
Fermented sorghum dough
Water
Starter (from a previous batch of *marisa*)

Method
Germinate damp grain for 2 days
Sun-dry and mill into a coarse flour, i.e. malt
Mix malt with cooked fermented dough, starter, and water
Let stand 4–5 days and serve, without filtering, for breakfast

Notes/Variations
This recipe involves three fermentation stages: (1) lactic fermentation of sorghum flour; (2) yeast starter activation; and (3) an alcohol

fermentation. A red sorghum variety, Feterita, is normally used. Similar beer preparations are used in many countries.

Busaa (beer made with sprouted grain)

Ingredients
4 kg sorghum flour
1 1/2 kg millet
2–4 litres water

Method
Mix flour and water to form a thick dough
Cover and put in a warm place and let stand for 4–5 days
Soak millet until it sprouts
Sun-dry sprouted millet and grind
Brown fermented sorghum mixture in a pan and stir until golden brown clumps form
Cool and gradually add water, while stirring to dissolve the flour
Add ground millet, and stir to a thick consistency
Keep in a warm place, preferably in a clay pot, 2–3 days
Strain, warm, and serve

Notes/Variations The sprouted millet acts as a yeast or malt to ferment the brew.

Uganda Similar steps are followed. Wood ash is sometimes added to give a dark brown colour to the beer. Stronger brews are made by sequential additions of flour or water and prolonged fermentation. For *omulamba* (a strong beer), the flour may be fermented 2 days, more flour added and fermented 3 days, and finally flour and hot water added for the last 12 hours of fermentation. Various mixtures of banana juice and maize or sorghum are used as well. The beer keeps 2–3 days, or if it is filtered and bottle-sealed, as long as 3 weeks. Beers similar to this are found in several countries.

Nigeria *Burukutu* and *buza* are related products. Honey is added to the *buza* during fermentation.

Potential for Improvement

Although on a world basis rice and maize occupy the largest areas of production, sorghum and millet are very important cereal crops in many parts of the world (Table 9). Within the developing world the area occupied by sorghum and millet greatly exceeds the area for maize. In fact if the American continent and China, where the millet grown is completely different from the pearl millet of the semi-arid tropics, are omitted then sorghum, millet, and maize are of roughly equal importance in terms of area cultivated.

However, yield differences for these crops are striking, especially between the developed and the developing world. Maize yields for example average 47 quintals/hectare (q/ha) in the developed world, 31 q/ha in the centrally planned states, and 13 q/ha in the developing world. The differences for millet are smaller, although the average yield in the developed world is twice that of the developing world. For sorghum, the difference was very large, 29 q/ha in the developed world compared with 8.5 q/ha in the developing world.

Thus, the yields of maize and sorghum could theoretically be trebled in the developing world, and that of millet doubled. This would greatly influence food production, and higher yields per hectare would allow farmers to reduce the area under cultivation, which would permit the growing of larger areas of crops for cash production, or the resting of larger areas of land as part of the important process of restoring soil condition and fertility. Basically, the better yields of cereals in the developed world have come about by the development of cultivars that respond to better farming methods. This makes it possible to use increased inputs profitably, and so the upward spiral is created.

As an example, yields of sorghum cultivars in the USA in 1950 were about 12 q/ha. The same land under modern sorghum hybrids now yields about 30 q/ha, largely because the modern sorghum genotypes respond well to fertilizer and good management. It now pays the farmer to spend more money and effort on this crop. This is why plant breeding projects aiming at developing better, more responsive cultivars are very important, and why projects to develop improved farming through the use of such cultivars are also of great value.

Yield differences give an indication of the differing ecological habitats of these cereal crops. Rice needs plenty of water and few people would attempt to grow maize in a flooded rice paddy. Similarly, millet is able to grow with relatively little water on alkaline soil, and few people would attempt to grow a maize crop on the dry light sandy millet soils of the world. (Irrigation may totally change the picture; for example, as soon as irrigation was introduced into the sorghum areas in India, the sorghum was largely replaced by wheat.)

The cereal type grown must, therefore, match the growing conditions. If reliable and good yields are to be obtained on the rain-fed, heavier soils of the dry tropics, then sorghum must be grown. Maize, on the other hand, will only yield well in favourable seasons, and will fail completely in others. It is therefore

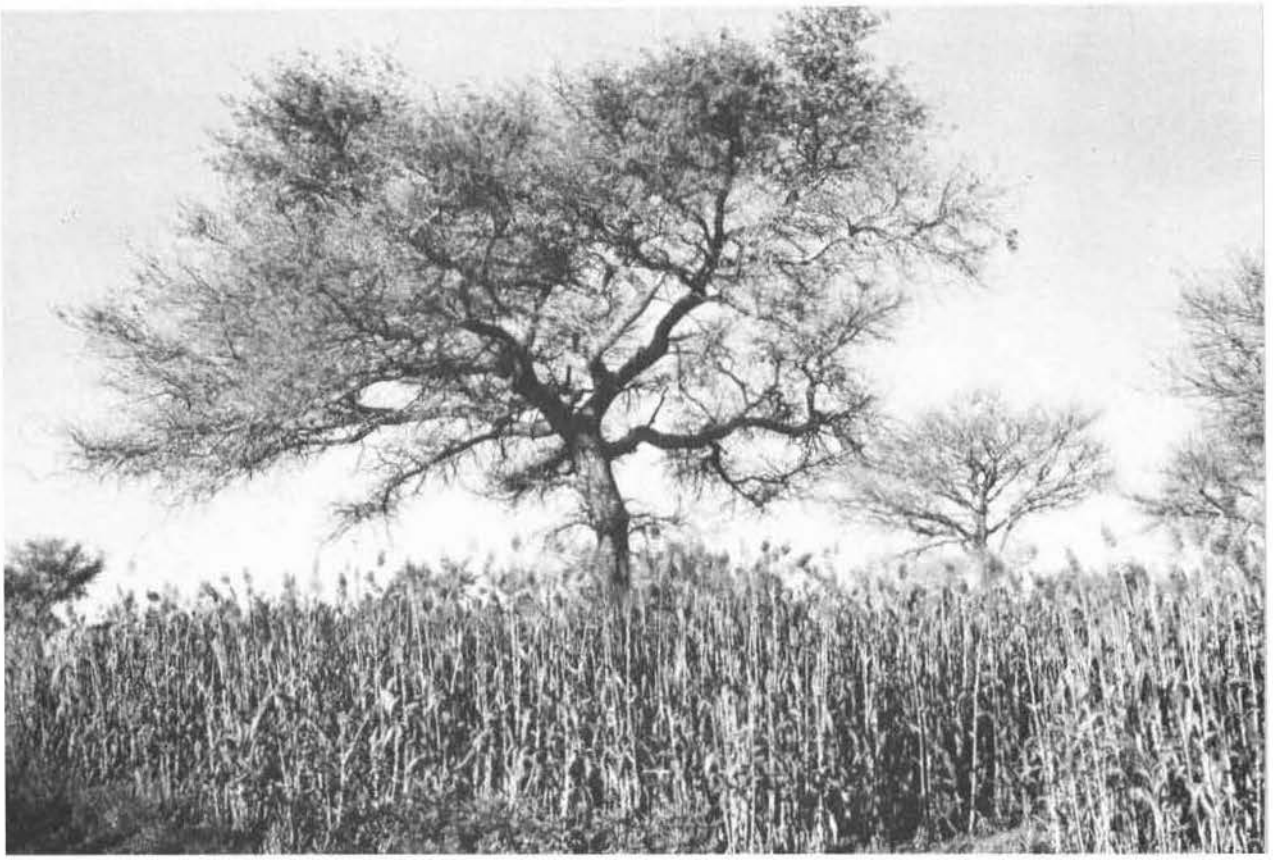
Table 9. Area (000's ha) under cereal production in major geographic regions. Total production figures are followed by selected national data (derived from FAO Production Yearbook 1976).

	Sorghum	Millet	Maize	Rice
Africa	**13940**	**16320**	**19650**	**4580**
Nigeria	5940	5000	1450	310
Sudan	2600	1200	85	7
Upper Volta	1140	910	90	40
Ethiopia	770	340	820	–
Niger	633	2530	7	20
Tanzania	600	200	1800	290
Mali	–	1240	90	150
Chad	–	900	10	50
Senegal	–	950	–	80
Asia	**18960**	**53190**	**28500**	**127160**
India	16000	20500	6200	38600
Yemen	2040	40	68	–
Pakistan	520	700	600	1700
China	10	30800	11550	35390
Korea	60	500	750	1970
N. America	**7760**	**1100**	**38300**	**1760**
USA	6020	620	28770	1010
Mexico	1180	70	7000	150
S. America	**2420**	**240**	**16500**	**7770**
Argentina	1830	230	2760	90
Brazil	190	–	11120	6590
World	**43930**	**72810**	**118050**	**142250**
Developed	6940	60	41160	4170
Developing	36680	38430	55240	94640
Centrally planned	310	34320	21660	43440
Asia and Africa (without China)	32890	38710	36600	–

undependable in such areas. In many countries, farmers have learnt this from experience over the years and the trend toward maize production is being reversed in favour of sorghum. As mentioned earlier, this is particularly true in Tanzania and Kenya.

Certain changes in characteristics of crop plants can be obtained by plant breeding, but it is not possible to change the fundamental nature of the crop plant. One cannot breed a maize type that can grow in a flooded rice paddy, nor can one breed a maize type that will give consistent yields on rain-fed, dryland light sands such as those on which millets flourish. There will always be extensive areas of the rain-fed tropics where sorghum and millet will be the main cereal crops.

Two major problems, causing severe yield loss of both crops, are birds and *Striga* (witchweed). Research is underway to solve the latter problem, but the bird problem is a much more serious one, and one that interacts with grain quality.



Increased sorghum production depends on the development of consumer-accepted varieties.

Unfortunately, the grain types that people like best are also those preferred by the birds. Birds represent the biggest problem for the sorghum and millet growers of the world today.

Usually, the development of continuous cultivated areas with little low bush and scrub helps to reduce the number of breeding and roosting sites for birds. Although they may still damage the edge of the cultivated areas, the damage they do overall is not serious. Reorganizing the countryside is part of the answer to the bird problem; for example, in Sukumaland, Tanzania, farmers eliminate a lot of the trees and bushes. This is not contrary to the forestry needs of the countryside because tree plantations can be located in blocks in suitable places, and therefore need not be a source of birds.

However, Africa has a particular problem of its own: a small weaver bird (*Quelea*) that multiplies in enormous numbers and moves in swarms like locusts. There seems to be no possibility of controlling these birds by reorganizing the countryside, and what will be required is the development of a cooperative scheme to control these birds over the whole continent.

The birds that damage the cereals are the grass-seed feeders. If there is plenty of grass seed, the bird damage is relatively less serious, although birds such as *Quelea* like the best quality sorghum and millet grains better than the grass, and can be a great source of trouble. "Best quality" means those grains that people like best. However, it is possible to find less palatable grain types that people can use as food, but which the birds do not like as much as grass seeds. Where these types are grown, the bird problem is only serious when the grass seeds have been eaten.

Many of the brown grains, white grains, or white grains with a dark subcoat, fall into this category. For example, in the highland areas of western Uganda, such types are grown, and in order to use them as food, they are germinated in damp wood ash, which helps to destroy the bitter polyphenols, and at the same time converts the starches to sugars. After being allowed to germinate for a few days, this malted grain is dried, ground, and made into a sweet porridge, which may be fermented for varying periods of time. Thus, in many areas where brown-grained sorghums are grown, although much of the porridge is eaten when the alcohol level is quite low, the people are said to live on beer. What is really happening is that the poeple have found a way to use food-grain types that the birds usually leave alone.

In projects in Nigeria and Botswana scientists have been learning how to remove the outer grain layers in a special mill that dehulls the grain. Hopefully it will be possible to do this with the grains that have a dark subcoat and are less susceptible to bird damage. At present, there are two problems in utilizing these grains: the subcoat layer is deep so wastage is high; and there seems to be some kind of close association between a rather soft grain and the presence of the subcoat, so that the grain crumbles and disintegrates when milled. The most radical attempt to solve the bird problem is a project in Canada where the somatic hybridization of maize and sorghum is being attempted.

There is so much genetic variability in the grain of the sorghum crop, and probably also in the pearl millet crop, that considerable improvements can likely be made in the grain quality of both sorghum and millet. For example, in rice protein there is no prolamine fraction, and in wheat the proportion of prolamine is relatively low. In sorghum and millet, on the other hand, the prolamine fraction may be more than half the total protein content. Work is being done at ICRISAT on sorghum types with a lower prolamine fraction than usual because the total protein in such sorghum grains is much more nourishing, but testing of such grain types for their food acceptability has not yet been done.

Another intriguing aspect of grain quality in sorghum is the attempt to bring together unusual characteristics to see whether a better grain type can be built. The discovery in Ethiopia of a cultivar with a flavour distinctly like the flavour of wheat, and the existence of some sorghums in Sri Lanka and northeast India that have an aroma of Bismati rice, present opportunities for grain improvement. These are very different sorghums, and it will take time to put the characteristics together in one grain type and to test whether it is superior to any of the existing sorghums. But the possibility does exist of producing better grains than those existing at present.

(Extensive use was made of the paper presented by Hugh Doggett in the preparation of this section.)

Role of Food Scientists and Home Economists

Because of their links to consumers, food scientists and home economists can be of great assistance in evaluating the consumer acceptability of cultivars developed in crop-improvement programs. At the same time as attempts are being made to develop improved grains, local varieties must be studied to identify both the grain characteristics and utilization of traditionally accepted varieties. The plant breeder can then try to make sure the identified characteristics are present in the new cultivars that are being developed.

Plant breeders work with very large numbers of genetically different lines; therefore, simple laboratory tests that can be easily applied to very large numbers of very small samples of grain are required. Cultivars that fail these laboratory tests can then be excluded from subsequent breeding studies allowing the work to continue on the others. From the laboratory determinations of grain characteristics that were used for selection earlier in the program, more than half of the lines available near the end stages of selection may be of good quality. When the program reaches the stage of testing only 25–50 possible lines, enough of each of these grains can be multiplied to carry out utilization tests.

At this point the varieties may be compared to evaluate their in-use performance. By comparing the quality of products made using the different varieties a better evaluation can be made of their prospective acceptance. This of course requires a larger sample of each variety than was required in the early stages of evaluation using laboratory tests on the grain itself. Subsequently three to five recommended lines can be evaluated in consumer-product tests to evaluate their acceptability. When a consumer-product test is conducted even larger quantities of fewer varieties are required. In this way each variety may be tested by 50–100 consumers.

While there is a general awareness of the benefits to be derived from such a broader-based selection program, there is a need to develop standardized test procedures. Research related to cultivar quality and use could help plot the cause/effect relationships between laboratory determinations of physical, biochemical, nutritional, and functional characteristics of the grains, the performance of these grains in utilization tests, and their consumer acceptability. Evidently many grain characteristics are involved: colour, fibre content, hardness, ease of grinding, starch type, endosperm structure, protein type, flavour, and aroma. Disease resistance, agronomic practices, and maturation time are other criteria of quality used in crop-improvement programs. Once the relationships between these qualities are established, they can be used by teams of agriculturalists and food researchers to screen cultivars for acceptability based on both production and consumption requirements for yield and utilization. Worldwide cooperation is needed to try to ensure that the new cultivars being developed have grain types that are acceptable to the consumers because people will grow grains that taste good, not only those that produce good yields.

Although a number of standardized laboratory tests have been developed to determine various physical, biochemical, nutritional, and functional characteristics of sorghum and millet grains, less attention has been directed toward linking these tests to utilization and consumer-product tests used to measure consumer acceptance. In the following two sections utilization and consumer-product tests are discussed in greater detail.

Utilization Tests

Cooking procedures are skill-oriented in most countries, with the techniques for food preparation being passed by observation from mother to daughter. In a standardized test, these cooking procedures must be specified and quantified to eliminate the skill components. In general, this involves selecting foods traditionally prepared in the home, and trying to reproduce them using a standardized laboratory procedure. Several steps must be taken to develop this procedure, which is called a utilization test.

1. Investigate Current Practices

Although it is normally fairly easy to list the common foods eaten in a particular area, it is necessary to be selective. Often there may be several different foods made from similar ingredients. For initial investigations, only foods that are served at least once each day should be chosen. Later, if a booklet of traditional foods is desired, less common recipes can be investigated. Common foods, once identified, should be listed along with an assessment of the skill required to make the food. It is best to start with the simplest preparations and progress from there.

The ingredients, amounts used, and common preparation methods for ingredients like flour should be noted as well. If the ingredients are purchased, the most common source should be determined. Next the preparation method and characteristics of the end product should be identified.

This involves selecting and observing one, or at most two, typical homemakers as they prepare the identified food. Measured amounts of each ingredient should be made available for the preparation. Dry ingredients should be weighed, and the weight or volume of any liquids on hand should be recorded. After the food is prepared, unused portions of the ingredients should be remeasured to determine how much has been used. Weights are preferable to household measures (handfuls, etc.) because the weight per unit of measure particularly for home milled flour will vary.

While the food is being prepared each step should be noted in detail as if nothing was previously known of the preparation. If bowls are used in the preparation, their full level capacity should be measured prior to the start of the preparation. Frequently a portion of the prepared mixture is set aside in the bowl during preparation, and a fairly accurate idea of that quantity is needed. Once the food is prepared the yield should also be established.

The homemaker should be asked if she is pleased with the resulting product because having someone watch her may have distorted her normal skills. She should be asked what tells her the food is good, bad, or indifferent, and casually

probed to determine how she judges the cooked food. The order in which she mentions product characteristics, should be mentally recorded as it indicates the relative importance of each characteristic. This information is then used as the criteria for product quality in subsequent laboratory work.

2. Standardize the Recipe

Next, ingredients identical to those used by the homemaker should be purchased in sufficient quantities to make the food twenty times in the laboratory. To reduce the variables in the recipe when home-milled flour is an ingredient, the homemaker should be asked to prepare the flour and then paid for this service.

Once the ingredients are collected, a "first run through" is done following the amounts and procedure recorded earlier. Hopefully, the resulting product will compare favourably with that made by the homemaker. If not, variables such as cooking heat, degree of beating, type of pot, temperature of water, and speed of preparation must be examined. The recipe is then repeated until identical products are obtained. Finally, the details of the modifications required to perfect the product are recorded.

Once satisfied with the product, an attempt should be made to simplify the procedure. Every step is looked at and checked for its necessity, keeping in mind that skill-oriented cooking has built-in safeguards. For example, the procedure might call for setting a portion of batter aside, adding ingredients such as flour to the remaining batter, and then adding the reserved portion until the desired consistency is obtained. With weighted ingredients, these precautions may not be necessary. As more analytical information is gathered on sorghums and millets, such as ideal cooking temperature for the flour and best flour particle size, further standardization and simplification may be possible.

To verify the final standardized recipe it is repeatedly prepared to ensure that an identical product is produced each time. If the product is replicable the recipe is reliable.

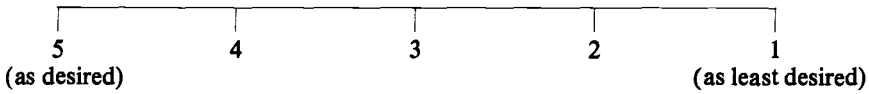
3. Develop Evaluation Procedures and Standards

Once satisfied with the standardized recipe, the resulting product should be tested by consumers. The initial step involves establishing criteria for consumer acceptability that reflect the consumers' not the researcher's preferences. Because of familiarity with certain foods and preparation methods, the researcher's standards may not be typical of the majority of the consumers. The end use of these evaluation procedures is to assist in the selection of new sorghum and millet varieties that are at least equal in acceptability to those in current use. A second purpose is to design a more objective rather than subjective evaluation procedure.

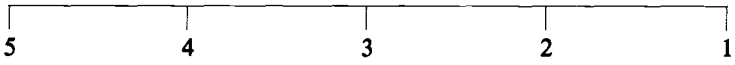
Although methods for establishing evaluation criteria vary with the particular product, the product prepared by the standardized procedure is generally taken to where 10–25 people can taste it. After tasting, the respondents are asked to compare the sample with what they normally have at home. For example, "Would you say this product, in comparison to that served at home, is: better than □; equal to □; or not as good □?" This can be followed by: "In what way would you say it differs?" If necessary, the interviewer should probe, and ask about the following: appearance — describe the difference; texture — describe the

1. EXTERNAL CHARACTERISTICS

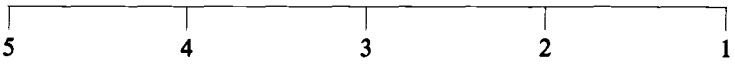
Colour



Texture

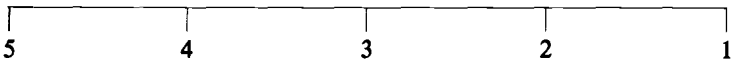


Shape

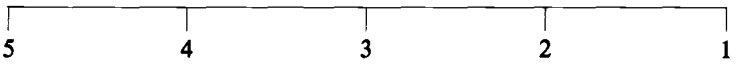


2. INTERNAL CHARACTERISTICS

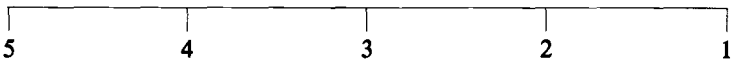
Colour



Texture

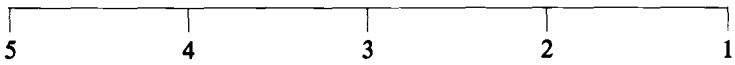


Crumb (Consistency)

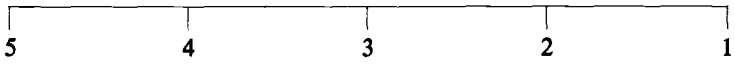


3. EATING CHARACTERISTICS

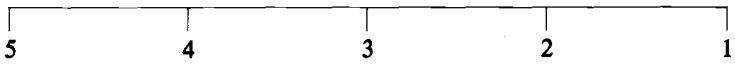
Aroma



Mouth Feel



Taste



Aftertaste

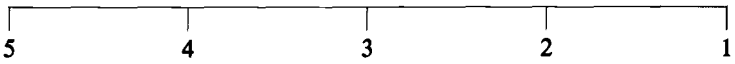


Fig. 1. Typical 5-score sheet on which the most important product characteristics are listed. Preferred qualities are given a higher score (in this case 5); the least preferred qualities lower values (in this case 1). Ratio: 1 = 30%; 2 = 30%; 3 = 40%.

1. EXTERNAL CHARACTERISTICS

COLOUR		
light	neither light nor dark	too dark

SURFACE		
smooth, glossy	neither	dry, cracked

SHAPE — N/A

2. INTERNAL CHARACTERISTICS

COLOUR — N/A

TEXTURE		
smooth or slightly granular	slightly too granular	lumpy or very granular

CONSISTENCY		
holds shape	flows slightly	too runny

3. EATING CHARACTERISTICS

AROMA		
characteristic of grain	no aroma or slightly off aroma	sour or off aroma

MOUTH FEEL		
smooth	slightly sticky	gluey, sticks to roof of mouth

TASTE		
bland, pleasant	slightly uncooked taste	raw starch taste

AFTERTASTE		
none	slight	bitter

Fig. 2. A 3-score sheet designed to be used when evaluating a stiff porridge.

difference; consistency — describe the difference; flavour — describe the difference; other — specify the quality and describe the difference. If it is necessary to suggest these categories, this should be followed by "Which do you consider to be the most important?"

From the basic information collected, a more objective, consistent, and consumer-representative evaluation procedure is developed. Often this can be used to identify physical characteristics, including: volume or yield; compressibility, fragility, flexibility; ability to hold shape; specific gravity (lightness); spreadability; rate of forming droplets; and pH of batter. When product standards have been developed, the products may be compared to these standards and rated as "good, so so, or poor." Three possible methods are: photographs; samples wrapped in film or pressed between glass and sealed with paraffin; and a pattern such as ink blots for texture.

In addition to objective evaluations of products, subjective panel scoring procedures are normally required. These are for test kitchen use only and are not for the general public. It may be that the researcher is the only person on the panel, but because scoring helps in evaluating products, it should be used.

To start designing a general score sheet (Fig. 1) list the most important product characteristics. This can then be modified according to the criteria of quality indicated by the 15–25 consumer respondents. It is important to be consistent in designing scoring sheets: if preferred qualities are on the left and undesirable ones on the right (as in Fig. 2, a scorecard for a stiff porridge) then each succeeding scoring sheet should be planned in the same manner. Numbers are then assigned to the rating system, usually from 1 to 5, in increasing order of merit. The ratings for the external, internal, and eating characteristics are done separately and then weighed to conform to the percentages noted on the bottom of the score sheet (Fig. 1).

The utilization test has been developed when a standardized procedure for preparing the product and methods for evaluating product quality have been established. This test may then be used to evaluate a number of sorghum or millet varieties. Initially, certain physical, biochemical, and functional determinations should be conducted on the flour or grain. These results in conjunction with the results of utilization tests and consumer-product tests should be used in evaluating the quality of grains. Although the majority of utilization and grain-characteristic determinations may be replaced by simple testing methods later, one or two usually remain as essential tests for evaluating the quality of different cultivars. When promising cultivars have been identified a consumer-product test can be conducted to give a further indication of acceptability.

Consumer-Product Tests

A consumer-product test is designed to gather information on a specific question, for example: "To assess the acceptability of a milled flour in comparison to a flour prepared in the household by traditional methods." A few basic "rules" should be kept in mind, which help to keep the questionnaire short, to the point, and effective: KISS — keep it short and simple; SQ = SA — stupid questions = stupid answers; SSSSS — smallest size sample that is statistically significant; and I/D — give preference to information over data.

The most common error in surveys or consumer studies concerns the use of the information obtained. It is important to gather only the information needed to solve the specific question — a lengthy questionnaire tends to supply inaccurate information. If the problem is complex it should be broken into segments.

1. Focus the Research Problem

Before a questionnaire can be developed, it is necessary to acquire background information on the project. In a study being done to assess the acceptability of mechanically milled sorghum or millet flour compared to a hand-processed flour in *tuwo* (stiff porridge), it would be necessary to know the traditional methods for making sorghum or millet flour in the home and details

about the utility of the mechanically milled flour being tested. As well, a comparative analysis of the two flours would be helpful.

Let us assume that the following background information has been gathered:

- Previous studies have shown that consumers consider that a test for sorghum or millet flour is its ability to make *tuwo*.
- The major use of sorghum or millet is in the preparation of *tuwo* with 25% of the sorghum or millet purchased by the households being used in its preparation.
- *Tuwo*, either prepared at home or purchased cooked, is consumed by 60% of the population.
- Of the five major foods prepared from sorghum or millet flour, *tuwo*, B, C, D, and E, *tuwo* is the most difficult to make, especially from a milled flour.
- In the past, commercially milled flour was too coarse and gave the *tuwo* a dark colour and a coarse texture.
- Technical refinements in the milling process, such as decorticating the sorghum or millet, using a finer milling process, the addition of a bleaching agent, etc., have eliminated these problems. As well, repeated taste paneling in the test kitchen of the mill has demonstrated this improvement. This testing, however, has been based on a standardized test-kitchen procedure, and the product must now be subjected to the skill-oriented procedure customary in the home.

Compiling background information like this often takes one from a general problem to a more specific one. Our question has in fact gone from sorghum or millet flour in general to sorghum or millet flour in *tuwo*.

An alternative might be: "The milled sorghum or millet flour performs or does not perform in an acceptable manner in the five major foods that use sorghum or millet flour." It should be noted that "acceptable manner" is used rather than "equal to traditionally prepared" because a slightly lower standard might be more attainable and sufficiently acceptable for a convenience food. In listing alternatives it is important to make decisions of this kind.

The next step is to try to prove or disprove these alternative statements by examining the background information, which suggests a focus on *tuwo*, but does not prove or disprove the alternatives. However, it does prevent unnecessary consumer-product tests from being done and tells us to conduct a test of milled sorghum or millet flour used for making *tuwo*. It is always necessary to focus the study. In this case, the background information focused on *tuwo*; if it had not, a separate step to sharply define the study would have been required.

2. Identify the Sample Population

Once the subject of the study is clearly defined, the population to be studied must be identified. In this case the sample population would be the people who buy and use sorghum or millet flour, and who eat *tuwo* or serve it at least occasionally in the home. Although the *tuwo* sellers in the market place might have been tested as well, it is a good idea to avoid including two such diverse groups in the same study because their standards of evaluation would likely be quite different.

To be even more explicit, the population might be defined as homemakers under 35 years of age (those likely to change), living in urban areas (more easily reached by the distribution network for milled flour), and employed outside the home or in a cottage industry (more susceptible to the pressures of time).

SAMPLE QUESTIONNAIRE

Good afternoon. I am _____ of the _____.

We are doing a study on *tuwo* and I wonder whether you would be willing to help us by answering a few questions and also by trying a flour in your home?

INSTALLATION QUESTIONNAIRE

1. May I have your name? _____

2. Do you do the cooking for the family?

YES ☐ NO ☐

IF THE RESPONSE TO QUESTION 2 IS NO, COLLECT INFORMATION FROM PERSON WHO DOES THE COOKING

3. Number in household eating from the same pot _____

4. About how many times a week do you eat *tuwo*?

SEVEN OR MORE TIMES ☐
FIVE TO SEVEN TIMES ☐
THREE OR FOUR TIMES ☐
ONCE OR TWICE A WEEK ☐

NEVER ☐
END INTERVIEW AND
RECORD AS NON PARTICIPANT

5. Do you usually buy *tuwo* or not?

YES ☐ NO ☐ GO TO QUESTION 8.

6. Which of the following is the prime reason for buying *tuwo*?

IT SAVES BUYING MANY INGREDIENTS ☐
IT IS TEDIOUS, UNINTERESTING TO MAKE ☐
IT SAVES TIME AND EFFORT ☐
I PREFER THE TUWO I BUY ☐
OTHER (PLEASE SPECIFY)_____

7. About how much does it cost for enough *tuwo* to feed your family?

N ____ : ____ K GO TO QUESTION 9.

8. Which of the following is the prime reason you usually make *tuwo*?

IT SAVES MONEY TO MAKE IT ☐
MY FAMILY PREFERS THE TUWO I MAKE ☐
BECAUSE I KNOW WHAT IS IN IT ☐
WE LIKE IT HOT ☐
I ENJOY MAKING IT ☐
OTHER (PLEASE SPECIFY) _____

9. For *tuwo* made at home, how many level full milk tins of sorghum are prepared for the family per meal?

_____ TINS NEVER MAKE ☐

HERE IS A BAG OF SORGHUM FLOUR WHICH WE WOULD LIKE YOU TO TRY. WE WOULD LIKE YOU TO USE IT IN THE NORMAL WAY YOU PREPARE TUWO. WOULD YOU BE WILLING TO TRY THIS FLOUR?

YES ☐ | NO ☐ END INTERVIEW AND RECORD AS NONPARTICIPANT

CALL BACK QUESTIONNAIRE

10. Have you had a chance to make *tuwo* from the flour that was left?

YES ☐ | NO ☐

IF THE ANSWER IS NO, THEN THE FOLLOWING TWO QUESTIONS APPLY:

(a) When might you expect to have tried the flour _____

(b) Would it be all right if I returned on _____

11. How did you find the flour to use? Would you say it was:

EASY TO USE	☐
NEITHER EASY NOR DIFFICULT	☐
DIFFICULT	☐

12. What did you like most about the flour?

_____

_____

13. What did you like least about the flour?

_____

_____

(Note: Because open-ended questions should be asked before close-ended questions, Questions 12 & 13 should precede Question 11.)

14. How was the *tuwo* made from the flour in comparison to that you normally serve? Would you say it was:

A		OR	B	
SUPERIOR	☐		MUCH BETTER THAN	☐
EQUAL TO	☐		A LITTLE BETTER THAN	☐
INFERIOR	☐		ABOUT THE SAME AS	☐
			ALMOST AS GOOD AS	☐
			NOT NEARLY AS GOOD AS	☐

15. Regardless of your overall comparison of the *tuwo* with what you usually serve, would you say that the _____ was
(insert colour, shape etc. in turn)

	Colour	Shape	Retention	Texture	Flavour	Aroma
MUCH BETTER THAN	☐	☐	☐	☐	☐	
A LITTLE BETTER THAN	☐	☐	☐	☐	☐	
ABOUT THE SAME AS	☐	☐	☐	☐	☐	
ALMOST AS GOOD AS	☐	☐	☐	☐	☐	
NOT NEARLY AS GOOD AS	☐	☐	☐	☐	☐	

16. Did you find the amount of water given in the instructions to be

TOO MUCH	☐
JUST RIGHT	☐
TOO LITTLE	☐

17. Did you have enough *tuwo* for your family or would you say you had

TOO MUCH	☐
JUST RIGHT	☐
TOO LITTLE	☐

18. Taking everything into consideration, how would you rate the *tuwo* made from the flour? Which of the following statements would best indicate your feelings about this product?

EXCELLENT	☐
EXTREMELY GOOD	☐
VERY GOOD	☐
QUITE GOOD	☐
FAIRLY GOOD	☐
FAIR	☐
POOR	☐

(Note: Because general information should be asked before specific information, Question 18 should follow Question 10.)

19. What do your consider to be a fair price for this flour in a bag the size you had?

N____ : ____K

20. Which of the following statements would best describe your likelihood of buying this flour if it were sold at N____ : ____K.

I WOULD DEFINITELY BUY	☐
I WOULD VERY LIKELY BUY	☐
I MIGHT OR MIGHT NOT BUY	☐
I AM NOT LIKELY TO BUY	☐
I DEFINITELY WOULD NOT BUY	☐

21. Have you any other comments that might be helpful to us?

_____

_____

At this point, it is easy to determine the kind of test we want. We need an in-home test because we require the homemakers to actually try the sorghum or millet flour in the preparation of *tuwo*. If the study showed that the *tuwo* did not have an acceptable colour, then a subsequent test might be a simple taste test with a colour question included. This type of result is fairly typical, as one consumer-product test nearly always builds on a previous one. What is now required is to write a questionnaire that will gather the specific information we want (see p. 53–55).

3. Develop the Questionnaire

The first four questions are screening questions designed to select the participants who conform to the previously defined population. Questions 5 and 8 are grouping questions that divide the participants into those who make *tuwo* at home and those who purchase it. This division is made by first selecting those who eat *tuwo* and then by asking respondents who eat *tuwo* if they purchase it. The remainder, therefore, make *tuwo* at home. It is important to note that without "never" in question 4 the division could not be made. Every time alternative answers are given to a question, all options must be covered. Notice that nothing is taken for granted and "never make" is included in question 9.

Questions 6 and 8 are called motivation questions. It is a good idea to avoid asking "why" in English, and it is probably likewise advisable to avoid comparable words in other languages. Motivation questions, in general, have a greater likelihood of being inaccurate. Participants may give answers they think are expected, expecially if they are listed. It is often preferable to have an open-ended question such as: "What would you say was your prime reason for buying *tuwo*?" The type of question asked depends on why the question is asked. In this example, question 6 is designed to find out whether *tuwo* buyers might make it in the home if a simple-to-use flour was available (the same is true of question 8). Question 9 should give some idea of the size of the bag that should be used for marketing the sorghum or millet flour.

4. Evaluate the Questionnaire

Once the questionnaire is drafted, it can be evaluated by considering the following questions:

First of all, does it provide information over data? Preference should be given to information that implies intelligence and useful input for decision-making. Most data are demographic and if required should be obtained in a screening question used to separate the sample population into subgroups. Subgroups should be based on criteria known to determine product acceptability. In designing these questions it is important to be sensitive to the feelings of the participants. For example, North American women are reluctant to divulge their age, therefore, if age is to be used as a basis for defining population subgroups, respondents should be asked which age group they fall into. The categories are usually presented on a hand card such as:

In which of these age groups may I check you?

5	18–25 years
4	26–35 years
3	36–45 years
2	46–55 years
1	56 years and over

Because such questions are considered confidential, they are placed at the end of the questionnaire (the "hand card" technique also helps give the appearance of confidentiality).

Secondly, is the information unique to the problem? It is a must to avoid general information in favour of the specific. In the "call back" section of the questionnaire all the questions are specific.

Next, does the question encourage the respondent to give one of the possible answers? Equal importance should be given to all possible answers; for example, would you or would you not... In the example questionnaire none of the questions seem slanted, and the possible options for the answers seem to be adequately covered.

Is the information sought: factual, opinion, or motive? Questions should primarily seek facts and opinion. Motive questions beginning with "why" or "for what reason" are frequently avoided or yield vague answers. The motive questions in this questionnaire are numbers 6 and 8. Because they are in the installation part of the questionnaire they will probably not affect the "call back" questions. In general, motive questions should be avoided, and where used they should be at the end of the "call back" questionnaire or only in the installation one.

Will the answer be influenced by a desire for status or to impress the interviewer? In this case questions 6 and 8 may have status implications as there may be status in making *tuwo* at home.

How will the information obtained help solve the problem? The questionnaire tends to be weak in providing answers as to why *tuwo* made from milled flour is better or not as good as customary *tuwo*. The "liked most" and "liked least" questions are the only ones that might provide clues. However, these are open-ended questions and the answers should be more valid than a series of "why" or "for what reason" questions after the "colour, shape, texture" questions. For stiff porridge, shape retention and cracking rather than shape are appropriate.

A series of checks should now be done on the order of the specific questions. Are the first questions factual, easy to answer, and impersonal? The first five questions are impersonal (asking a person's name is considered as an impersonal question). Secondly, check to see that "if yes to question X" sequential questions are grouped together. There are several examples of different methods of doing this (Questions 4, 5, 7, 9, 10).

It is now necessary to check that overall evaluations are sought before more specific attributes. This in fact has not been done. Question 18 should be asked before question 11. Question 18 is designed to give a numerical (hedonic) rating to the overall results. This is done by multiplying the number of answers in each

Table 10. Method used to determine hedonic rating of a question such as number 18.

Choices	Responses	Responses × Rating Factor
excellent		_____ × 6 =
extremely good		_____ × 5 =
very good		_____ × 4 =
quite good		_____ × 3 =
fairly good		_____ × 2 =
fair		_____ × 1 =
poor	_____	_____ × 0 = _____
	Total A (total number of responses)	Total B (total of weighted responses)

Total A divided by Total B = X.XX (the hedonic rating)

category by a scoring number (for example, 6 to 0 with the number of people rating the *tuwo* as excellent multiplied by 6 down to the number rating it as poor multiplied by 0). The numbers generated by this procedure are totaled and then divided by the total number of respondents to give the final rating (see Table 10).

The questionnaire should also be reviewed to ensure that "open-ended" questions come before "closed-ended" questions. Again a fault is evident in the questionnaire. Question 12 is open-ended, and if it remained after "How did you find the flour to use" almost all the answers would be "it's easy to use."

As a final check, make sure that personal questions (generally demographic and especially family income) are at the end of the questionnaire. No questions of this type have been included in this questionnaire.

The questionnaire itself has been examined on a general basis; now it is necessary to objectively examine the use to be made of the information gathered from each question. In our example, the installation questions provide marketing information on size of bag, price, and details helpful in promoting the sale of flour. In the "call back" section, all the questions evaluate the flour except numbers 16, 17, and 19, which give information on package size and directions. In other words, each question has a purpose.

Before taking the questionnaire to the public, it should be tried on at least three or four people whose reactions to each question should be assessed. It is important to watch for long pauses before answers are given or for answers that do not truly respond to the question. With experience it may be sufficient to have someone read the questions to you, time the interview, and carefully observe your reaction to each question. One question that creates resentment or seems superfluous can distort the answers to all the questions that follow.

5. Tabulate the Results

Once the interviews are completed, it is necessary to verify that the individuals delegated to interview the participants actually did so. This, in fact, is one of the most important aspects on any consumer study. It is generally sufficient to contact about 5% of the participants and ask them an additional question (with the offer on another bag of the product) plus one of the original questions to verify their response.

To tabulate the results, the first step is always to number the questionnaires. Subgroups may be sorted out before the numbering based on the responses to the screening questions. Different colours of ink may be used to number and tally the responses for separate population subgroups. For example, persons who do or do not buy *tuwo* (see question 5).

In devising a tally sheet, each question should be listed with the available or anticipated choices. Marks are made by each choice as the questionnaires are analyzed, and finally the responses are tabulated to give the total number of responses for each choice.

For a closed-ended question like number 3, the tally sheet would be quite simple (Table 11). Sometimes a particular question is of interest in relation to another question. For example, the cost of feeding *tuwo* to the family (question 7) is meaningful only when family size is considered (question 3). To tally question 7, the response to question 3 is taken into consideration. The tally sheet that would be used (Table 12) separates the cost to feed the family into family-size categories. A similar method would also be used when tallying question 9.

For open-ended questions recurring answers are selected by glancing through the questionnaires. For the "most liked" question (number 12) the tally sheet would be like the one shown in Table 13. Question 13 would be tallied in a similar manner.

As stated earlier, comparison questions (like numbers 15 and 18) are weighted by multiplying each response by a corresponding value. On the tally sheet, question 15 would have the categories colour, shape retention, texture, flavour, and aroma with the three to five possible choices given for each of them. When multiplied, added, and divided, the individual characteristic ratings can be compared to the overall rating to check for response validity (Table 14).

Table 11. Tally sheet for question 3, a "closed-ended" question asking the number of people in the household.

Choices	Responses
0–3	
4–6	
7–12	
13–20	
20 and up	

Table 12. Because the cost to feed a family is most meaningful when family size is taken into consideration, the tally sheet for question 7 combines these two pieces of information. Cost in this case is expressed in kobo (Nigerian currency).

Responses	Responses
0–3 people	**13–20 people**
0–9	0–44
10–14	45–54
15–25	55–64
25–34	65–74
35–up	75–84
	85–99
	100–119
4–6 people	120–139
0–14	140–149
15–24	150–up
25–34	
35–44	**20 or more people**
45–54	0–59
55–up	60–79
	80–99
	100–119
7–12 people	120–139
0–24	140–159
25–34	160–179
35–44	180–200
45–54	200–up
55–64	
65–74	
75–84	
85–99	
100–up	

Table 13. For an "open-ended" question, recurring answers are selected and listed, and the responses to each question are tabulated.

What did you like most about the flour?	Responses
Speed and convenience	
Colour	
Results	
Flour was free	
Package	
Easy directions	
Other	

Table 14. To tabulate the results for questions about specific characteristics, the options are listed and the responses to each option are recorded.

	Responses
Texture	
Much better than	
A little better than	
About the same as	
Almost as good as	
Not nearly as good as	
OR	
Superior	
Equal to	
Inferior	

6. Draft Report

The very last step in the consumer-product test is to draft a final report of the test. This should include the results, an evaluation of the results, a suggestion of which of the alternative solutions seem advisable, a summary of the background information, and recommended action.

A few general points should be kept in mind:

- Effect of status — sometimes the food or product may be considered a status symbol, which will distort usage figures (e.g. bread).
- Relation to market — a paired comparison considers only two products and does not reflect the market where several products vie for the customer's favour.
- Monadic tests (where only one product is presented) will have a higher numerical rating than products in a paired comparison.
- Not always does the stated criticism apply — for example, comments on artificial flavour may be linked to too strong a colour.
- Confusing results indicate that unimportant criteria are being questioned or that criteria selected do not conform to consumer's ideas.
- Results in the same questionnaire may not conform to the halo effect — for example, in a paired comparison watch for criteria of evaluation that do not conform to overall preference.

Although the example test questionnaire was developed for flour, a similar procedure may be used to evaluate other products, including new cultivars. In this case the questions would relate to the cultivar used as flour rather than a flour used

to prepare a product like *tuwo*. The value of grain-characteristic, utilization, and consumer-product tests cannot be underestimated. Without them, product development would be at best chancy; with them, new products can be successfully introduced, and new varieties can be integrated into the market system. With these methods, feedback from consumers can be incorporated into breeding programs and, as a result, grains with the characteristics most desired by the consumers can be developed.

After a recommended cultivar has been identified, an educational program to introduce and advertise the new variety is required.

Both producers and consumers will need information about what to expect when using a particular product or cultivar. For example, if an introduced cultivar makes a bread similar in characteristics and quality to traditional breads but comes in a form slightly different than usual (a different shape, colour, etc.), the farmer and the cook need to be advised of this ahead of time. This will help ensure a market for the crop once it is harvested. Similarly, if the crop will be made available as an already dehulled and ground flour, rather than just as an unprocessed kernel, consumers need instructions regarding its use. Of help would be advice about modifications required in the method of preparation when using the new product in traditional recipes, and again a warning of product characteristics that may be expected to differ from those of the traditional end product.

A few minutes of introduction and instruction on how to use and what to expect from an introduced cultivar can make the difference between its acceptance or rejection. Even if the cultivar is expected to be desirable and readily accepted, the manner in which it is introduced can either promote or deter its subsequent acceptance.

(Extensive use was made of the paper presented by Sally Henry in the preparation of this section.)

Conclusions and Recommendations

Sorghum and millet are crops very well adapted to the ecological conditions under which they are traditionally grown. They thrive where other cereals do poorly, and their replacement in these situations leads to uncertain yields. They are the "way of life" of the people in some countries like Nigeria, and are considered the "food of the people" in the Sudan. Their traditional role in the life of people in all the areas is reflected in their use in traditional dishes (common to many countries), and their inclusion in religious rites, traditions, and kinship patterns.

Equally important are the uses of the by-products from these two cereals. Their use as fence posts, as firewood, for thatching roofs, for making children's toys, as animal feeds — all these are considerations that must be fully evaluated when attempting to breed, develop, and introduce new "improved" varieties. Experience has already shown that although grain production per se may be higher, short-stalked sorghums for example may not be liked because they do not produce useful by-products.

Plant breeders are optimistic that opportunities exist to improve these crops, but they require more specific information on the consumers' likes and dislikes. Once these aspects of quality are defined they can be used as criteria for selection in crop-improvement programs. With this information, the plant breeder will be able to balance his program between quality and yield. At the same time, work is obviously required to improve processing methods, to reduce the effort involved, and also to develop new products from these traditional grains. With the correct focus on research it may well be possible to reverse the trend toward growing maize and rice in areas where they are not ideally suited, and to foster the growth of sorghum and millet.

These kinds of concerns were reflected in the workshop discussions, and it was concluded that there is a need and potential for the strengthening of the links between sorghum and millet breeders, food scientists, home economists, and other scientists involved in postproduction systems, and the commercialization of the processing of sorghum and millet products.

In fact, one of the main difficulties in the commercialization of sorghum and millet products is the lack of strong links among the various interested groups. There is, therefore, tremendous potential for development if effective links can be created. Examples of the type of links that are required can be found in many maize, wheat, and rice improvement programs. Unfortunately, bonds between scientists in sorghum and millet improvement programs are comparatively less established. Part of the reason for this is that sorghum and millet are not commonly consumed in the countries where these scientists have been trained. This means that the built-in associations with other aspects of the postproduction system available to scientists studying maize, wheat, or rice are not available.

Fortunately, it is possible to develop the required degree of cooperation, and this desire was evident in the recommendations presented by the workshop participants.

To strengthen the links between sorghum and millet breeders, food scientists, home economists, and other scientists involved in the postproduction aspects of these crops, the following courses of action were recommended:

- food scientists and home economists should become involved in conducting utilization tests for screening sorghum and millet cultivars
- existing sorghum and millet improvement programs should be expanded to include policymakers, food scientists, home economists, and extension and marketing personnel
- funding agencies must be encouraged to provide assistance on a national level for the support activities that foster this type of information exchange and cooperation
- the proceedings of the workshop should be published and distributed to institutions conducting related research

To commercialize the processing of sorghum and millet products, research must be conducted to investigate the quality, processing, and products of these grains. Specifically recommended was research in the following areas:

Quality

- the determination of the criteria of quality for sorghum utilization
- the development of utilization tests applicable to a wide geographic area for frequently consumed products affected by cultivar variety (these tests would be based on standardized recipes for the products)
- the development of objective tests for determining utilization criteria to be used along with production and storage criteria for screening varieties in crop-improvement programs

Processing

- the determination of the bacteriological, microbiological, and biochemical changes occurring in traditional processes and products
- the modification of traditional processes to increase convenience and shelf life and to standardize the quality of traditional products (starting with flour)
- the establishment of small-scale pilot processing plants to determine the operational and economic feasibility of modified processes for producing sorghum and millet products

Products

- the modification of recipes for other cereal flours by using sorghum and millet flour
- the development of other products using sorghum and millet (for example, children's foods and breads are being developed in Hyderabad and Khartoum)
- the marketing of test products to assess acceptability, starting with one product and process